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CONTENTS

What Metering Has Done for the Evansville, Indiana, Water Works. By CHARLES STREITHOF 371

The Water Supply of the City of Los Angeles with Particular Reference to the Area Supplied by Pumps. By WM. W. HURLBUT 379

The Sensitivity of the Ortho-Tolidine and Starch-Iodide Tests for Free Chlorine. By A. M. BUSWELL AND C. S. BORUFF 384

Softening Public Water Supplies. By JOHN C. WHITE ... 406

Composition of Mud Balls. By W. S. MAHLIE 420

Chlorophenol Tastes in Milwaukee's Water Supply. By RUSSELL W. CUNLIFFE 423

More Typhoid Fever From Cross-Connected and Dual Water Supplies 435

Treated Water in Swimming Pools. By F. H. STOVER ... 440

Alum Floc: What Is It? By WILLIAM D. HATFIELD 442

Obituary, George H. Benzenberg 476

Superintendent's Question Box Series

- Planning for the Future 448
- Tunnel Construction in the Water Works of St. Catherines 450
- Meter Troubles 451
- Cleaning Intake Pipes 452
- Pitometer Surveys 453
- Tastes and Odors 458
- Sizes of Services for Flushometers 462
- Rules and Regulations Governing Plumbing 466
- Bypassing Large Meters During Emergency Repair .. 474

Abstracts 478

Society Affairs 498

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VOL. 14 NOVEMBER, 1925 No. 5

WHAT METERING HAS DONE FOR THE EVANSVILLE, INDIANA, WATER WORKS[1]

BY CHARLES STREITHOF[2]

The original plant of the Evansville, Indiana, water works was put in operation in 1873. The present pumping station (now serving a population of 100,000) was put in operation in 1892. The filtration plant was put in operation on March 20, 1912. The plant is situated on the Ohio River about a mile and a half from the business center.

The pumping machinery consists of two Holly vertical triple expansion differential plunger pumps. Diameter of plungers 19¼ and 27½ inches by 48-inch stroke, capacity of each unit per 24 hours 12,000,000 gallons, against a dynamic head of 125 pounds per square inch; two Holly steam turbine driven double stage centrifugal pumps, R.P.M. 900, capacity 15,000,000 gallons per 24 hours against a dynamic head of 140 feet, used as a reserve pump; two DeLaval steam turbine driven single stage centrifugal pumps, R. P. M. 900, capacity 15,000,000 gallons per 24 hours against a dynamic head of 63 feet. These pump water from the river to the filter plant.

The boiler plant consists of 4 water tube Class A special water tube No. 18 and No. 21 Sterling boilers, bought from Babcock and Wilcox Co., horsepower, three 260 each and one 308.

[1] Presented before the Joint Meetings of the Illinois, Wisconsin and Iowa Sections, March 18, 1925.

[2] General Superintendent, Water Department, Evansville, Indiana.

The filtration plant is of the rapid sand filter type.

The original filter plant has a capacity of 12 million gallons per 24 hours. To this plant was added in 1924 an additional 6 million gallon capacity, making a total of 18 million gallons at present. The entire filter plant is equipped with all modern devices for turning out first class water. It was designed by Alvord, Burdick and Howson, and built under their supervision.

The distribution system is in one piece, and is supplied from the main pumping station through three 30-inch force mains. There are 161 miles of pipe, varying in size from 4 to 30 inches, with 1204 fire hydrants, 81 automatic sprinkler services, and 18,560 service connections.

Prior to 1914 there were 30 large water meters in service. It was found impractical to use water meters before the Ohio River water was filtered. After the filtration plant was completed, the water works managers were of the opinion that, on account of the clear and pure water which was then provided, the waste of water would be curtailed and the daily pumpage reduced. This prediction failed to materialize, as the water consumers on the flat rate basis wasted just as much water as they formerly did with the unfiltered water.

It was soon found that the new filtration plant was entirely too small to meet the growing demand. In 1914 the water board decided to purchase a sufficient number of meters to take care of the large consumers. After these had been installed a marked reduction in the pumpage was noticed at night. In 1915, 2200 meters were installed in the southeast residential district, and from then on until the end of 1924 meters were installed at the rate of 2000 per year, thus completing the metering of the entire distribution system.

It may be of interest to know that the water department collected on the flat rates in the above named district an average of $13.16 per consumer. After the meters had been in service for one year, we found that we were only getting $6.62 per consumer. A slight raise was ordered in our meter rates in 1917, which rate prevailed until April, 1923, when the Public Service Commission again granted us a small increase.

The present rates are as follows:

$0.25 per 1000 gallons for first 5000 gallons used monthly.

$0.20 per 1000 gallons for the next 20,000 gallons used monthly, after the first 5000 gallons.

$0.15 per 1000 gallons for the next 75,000 gallons used monthly, after the first 25,000 gallons.

$0.10 per 1000 gallons for the next 200,000 gallons used monthly after the first 100,000 gallons.

$0.08 per 1000 gallons in addition to the first 300,000 gallons used monthly.

Annual service charge (for service only and includes no water)

SIZE OF METER	CHARGE
inches	
$\frac{5}{8}$	$3.00
$\frac{3}{4}$	3.00
1	5.00
$1\frac{1}{2}$	6.00
2	8.00
3	15.00
4	24.00
6	40.00

Prior to 1914 the average daily pumpage, with 7160 water consumers was 9,797,800 gallons; in 1924 the daily average pumpage with 18,412 consumers (all metered) was 7,190,461 gallons. The records of the water department for 1924 show that the peak load of pumpage during the day time reaches as high as 18 million gallons, and the average night load between 9:00 p.m. and 6:00 a.m. an average of 1,378,600 in nine hours. Prior to the installation of the meters the night load was almost equal to the day load.

The total cost of installing the meter system up to January 1, 1925, was $249,217.81, and it has proved a good investment for the department as well as the consumer.

How the entire city benefited by curtailing the waste of water can readily be seen. In 1911 the National Board of Fire Underwriters made a general inspection of the city and reported the water works system in Class 5; in 1919, a second inspection was made and due credit was given the work of meter installation, and the department placed in Class 3. A third inspection was made in 1923 and the water works system was advanced to Class 1. In October, 1924, the entire city received the benefit of a reduction of insurance ranging from $6\frac{1}{2}$ to 15 per cent.

The Evansville water works is the only water plant in the middle west, according to the records of the National Board of Fire Underwriters, which enjoys the rating of Class 1.

Furthermore, had the department not commenced to install the meters when they did, they would have been compelled to increase the capacity of the filter plant almost as soon as it was completed, or been compelled to mix raw river water with filtered water part of the day.

How water is pumped and accounted for

Water is pumped by the low lift pumps through a 30 inch low pressure Venturi meter. The high lift pumps take the water from the clear water reservoir and discharge through a 30-inch high pressure Venturi meter. Both of these were built by the Builders Iron Foundry.

		PER CENT
Total gallons pumped in 1924	2,631,708,820	
Water passed through meters	1,703,032,000	64.7
Estimated water (meters out of service)	30,000,000	1.1
Consumed at filter plant	109,731,521	4.2
Flushing streets and wharf levy	109,500,000	4.2
Water troughs	18,250,000	0.7
Fire loads	32,000,000	1.2
Parks, swimming pools, engine houses and city buildings	20,000,000	0.7
Unaccounted, underground leakage, etc	609,195,299	23.2
	2,631,708,820	100.0

Per capita consumption

	GALLONS		NUMBER OF METERS
1910	124	No filtered water	0
1915	107	Filtered water	2,181
1920	94	Filtered water	7,703
1924	74	Filtered water	18,412
Total number of meters placed in service			19,234

Of this number:
18,412 were in service January 1, 1925
3 were stolen
4 lost from trucks
288 were frozen (most of them in winter of 1917–1918 and were set in basements)
527 worn out and discarded

We are not satisfied alone by saving of the water, but have also started to save the coal pile. Since the new addition to the filter plant has been in operation, we experienced no trouble in keeping the clear water reservoir full.

On the night of January 1, 1925, we arranged to have the reservoir full to the top. At 11:00 p.m. the low service turbines and the filters were shut down and one boiler banked. This has been done

TABLE 1

Summary of meter statistics, Evansville, Ind.

1910 to December 31, 1924

1 YEAR	2 TOTAL CONSUMERS END OF YEAR	3 AVERAGE DAILY PUMPAGE (gallons)	4 TOTAL METERS END OF YEAR	5 PER CENT METERED END OF YEAR	6 METERS INSTALLED EACH YEAR	7 COST OF METER INSTALLATIONS EACH YEAR	8 LABOR COST OF SETTINGS EACH YEAR	9 COST OF METER SERVICE EACH YEAR
1910	7,620	8,703,462	36			$2,050,47		
1911	7,800	9,779,917	45		9	1,967.60		
1912	7,987	9,863,480	50		5	1,291.89		
1913	8,176	9,797,800	50		10	1,532.42		
1914	8,875	9,313,700	271	3.1	221	9,792.22	$4,959.43	$1,046.67
1915	10,680	7,813,100	2,181	20.4	1,910	20,848.32	2,114.10	1,992.43
1916	10,818	8,019,632	4,048	37.4	1,867	16,646,85	1,026.12	3,559.89
1917	12,461	8,752,930	5,403	43.4	1,315	12,913.23	920.25	4,066.41
1918	13,434	8,994,401	6,098	45.3	1,338	7,229.40	649.70	4,142.04
1919	13,987	8,121,746	6,867	49.2	758	9,983.69	824.61	4,375.52
1920	14,283	8,071,198	7,683	53.8	833	10,680.33	966.55	4,700.87
1921	15,199	8,119,610	8,627	56.8	967	16,491.03	1,169.05	5,431.26
1922	16,400	8,363,702	11,465	69.9	2,928	49,110.07	4,555.55	6,346.36
1923	17,322	8,298,902	16,052	92.6	4,458	59,934.98	4,363.55	7,706.22
1924*	18,412	7,190,461	18,412	100.0	2,385	31,829.89	3,263.00	7,309.40

Column 5 is figured from columns 4 and 2.

Column 7 includes entire cost of new construction.

Column 8 includes labor cost of new construction.

Column 9 includes maintenance, removing and resetting, reading, and meter and fittings department labor and expenses.

Total cost of meter construction to January 1, 1925—$249,217.81.

* December 31.

every night. The shut down varies from six hours to six hours and forty-five minutes. This effected an average saving of 6.9 tons per day during January and 5.8 tons during February.

No labor has yet been saved. It is my intention, however, to shut down eight hours each night; a saving then of $7.98 per day can be effected on labor.

We have just equipped both of our Holly Triple Expansion Pumps with Birch non-slip valves. A test run, on March 9 showed a differ-

TABLE 2

Size and number of meters installed each year, Evansville, Ind.

YEAR	NUMBER OF METERS INSTALLED EACH YEAR								TOTAL NUMBER EACH YEAR	LABOR COST EACH YEAR	TOTAL COST EACH YEAR
	¾ inch	¾ inch	1 inch	1½ inch	2 inch	3 inch	4 inch	6 inch			
1910											$2,228.89
1911									9		1,967.60
1912				1		3			5		1,291.89
1913									10		1,532.42
1914	21	40	63	43	48	5	1		221	$4,959.43	9,792.22
1915	1,473	426	117	56	71	11	24	3	2,181	2,114.10	20,848.32
1916	1,738	31	37	6	5		5	1	1,823	1,026.12	16,646.85
1917	1,254	22	15	6	6		10	2	1,315	920.25	12,913.23
1918	1,237	59	18	4	14	4		2	1,338	649.70	7,229.40
1919	704	22	16	1	10		5		758	824.61	9,983.69
1920	775	30	16	2	9		1		833	966.55	10,680.33
1921	922	28	12	1	2		2		967	1,169.05	16,491.03
1922	2,879	13	17	2	13		3	1	2,928	4,555.55	49,110.07
1923	4,358	18	29	18	27	4	3	1	4,458	4,363.55	59,934.98
1924*	2,346	1	24	1	13		3		2,388	3,263.00	28,566.89
	17,707	690	364	141	218	27	57	10	19,234		$249,217.81

Present cost of Tile Settings to city—$4.80 each.

Present cost of Pit Settings to city—$26.00 each.

Pit Settings are used for sizes over 1″ and are built completely by city.

Tile Settings—material furnished by city and meter set in place after consumer makes all connections.

Average Investment per Meter all sizes $12.95.

* December 31.

ence between the Venturi meter and the pump counter of 2.3 per cent, and between the Venturi meter and the clear water reservoir of 1.7 per cent.

The data shown in tables 1, 2 and 3 may be helpful in the above discussion.

TABLE 3

Cost of meter service

YEAR	MAINTENANCE	REMOVING AND RESETTING	READING	METER FITTING DEPARTMENT		TOTAL OF PRECEDING ITEMS
				Labor	Supplies and Expense	
1914	$ 435.02	$22.83	$ 253.35	$325.95	$ 9.52	$1,046.67
1915	761.88	123.95	746.95	165.80	193.85	1,992.43
1916	1,388.42	295.75	1,034.58	678.19	162.95	3,559.89
1917	1,628.01	359.50	1,417.15	544.94	116.81	4,066.41
1918	1,620.63	520.10	1,352.70	563.04	85.57	4,142.04
1919	1,824.78	431.35	1,444.60	656.13	18.66	4,375.52
1920	1,682.72	327.70	1,869.55	807.00	13.90	4,700.87
1921	2,272.51	288.20	2,016.00	832.00	22.55	5,431.26
1922	2,246.28	360.10	2,821.47	813.30	105.21	6,346.36
1923	2,846.54	120.00	2,872.00	1,850.00	17.68	7,706.22
1924	2,966.35	24.00	5,124.00	2,384.00	24.14	10,522.49

Meter and Fittings Department covers Stock Room expense.

Office labor not included in above items. Meter record Clerk receives $1,800.00 per year.

DISCUSSION

HENRY RINGNESS:[3] At Peoria we test every new meter and all old meters that come into the shop. All are set to read 0 when placed in service. We test at three different flows, one about equal to an ordinary leak in a toilet, second an average flow through that size meter and, third a maximum rate of flow. Tests show that meters usually register in favor of consumer. Daily report shows cost of setting and repairing meters. Meter history gives make, size, number, date of installation date of removal and of reset. On back of card is recorded test number and result of test.

The cost of repair is from $1.00 to $1.50. With a meter in very bad repair it might be considerably more. This does not include the cost of taking out and replacing the meter which costs about $1.00 additional. The company pays the cost. The meter is furnished, set and repaired by the company at its own expense.

L. R. HOWSON:[4] Mr. Streithof's paper shows very clearly what has been accomplished at the Evansville Water Works by metering.

[3] Superintendent of Accounts, Peoria Water Works Co., Peoria, Ill.

[4] Alvord, Burdick and Howson, La Grange, Ill.

Mr. Streithof's figures are on the per capta basis, which leaves out of consideration the fact that, due to the installation of filters and the resulting better water supply, the ratio of population to consumers was materially lowered during the period when meters were being put in. In 1910 the average daily pumpage per consumer was 1145 gallons. At the present time it is only 390 gallons, or approximately 34 per cent of what it was when metering was started.

Mr. Streithof states that his average income per consumer was approximately $13.00 before metering and $6.60 after metering, a saving of $6.40 per consumer, which applied to the 18,000 meters represents a net saving to the consumer of $118,000 per year. Consumers themselves could well have afforded to have paid for the meters, as the entire cost of the meters and setting would have returned to them in lowered bills within three years' time. From the city's standpoint the installation of meters has resulted in immense savings through deferred construction expenditures, as so ably pointed out by Mr. Streithof.

At Ashland, Ky. metering reduced the consumption per consumer from approximately 500 to 339 gallons per day.

At Ironwood, Michigan, metering was started in June 1923. At that time there were only 72 meters on a total of over 2500 services. The consumption at that time averaged 853 gallons per day per service. In a period of 13 months 2729 meters were set, and at the end of that time the consumption averaged 394 gallons per day per service. The pumpage was more than cut in half in a period of two months. In this plant the water is pumped against a head of 650 feet, and this saving in pumpage amounts to a reduction in the power bill of approximately $12,000 per year.

New Orleans through metering reduced its water use from 1290 to 470 gallons per consumer per day.

Numerous other instances of savings of this same type are available.

THE WATER SUPPLY OF THE CITY OF LOS ANGELES WITH PARTICULAR REFERENCE TO THE AREA SUPPLIED BY PUMPS[1]

By Wm. W. Hurlbut[2]

The total area of the main portion of the City of Los Angeles which is served as a domestic supply by the Bureau of Water Works and Supply amounts to 144 square miles of which 30 square miles is hill area supplied by pumped water.

These zones vary in elevations from 613 feet to 938 feet above sea level. In addition to the above-mentioned area the San Fernando Valley comprising 180 square miles is completely served by a combined irrigation and domestic system. The source of this supply is that of the Los Angeles Aqueduct.

The Los Angeles Aqueduct enters the San Fernando Valley discharging into the Upper San Fernando Reservoir and thence into the Lower Reservoir, also a diversion conduit is built westerly along the foothill slopes of the north rim of the Valley to the Chatsworth Reservoir, and on the south side of the Valley, nestled in a cove on the northern slope of the Santa Monica Mountains we have the Encino Reservoir. These four reservoirs take care of the demands of the San Fernando Valley, as well as providing reserve storage for the City proper.

The Aqueduct supply reaches the City proper via Franklin Canyon at an elevation of 575 feet, Stone Canyon at an elevation of 850 feet, and Hollywood Reservoir at 750 feet, all three storage basins lying on the Southern slope of the Santa Monica Mountains.

The Franklin Canyon supply serves the entire Hollywood section and in addition thereto discharges into the high gravity (elevation 448 feet) and the low gravity (elevation 378 feet) systems.

The new Hollywood Reservoir (elevation 750 feet) is a supply for the Hollywood Hill area, which district, at the present time, is served by the Las Palmas Pumping Plant.

[1] Presented before the California Section meeting, October 23, 1924.

[2] Office Engineer, Bureau of Water Works and Supply, Los Angeles, California.

The old supply of Los Angeles is derived from the Los Angeles River through the headworks and the Crystal Springs Plants. The headworks diversion being that known as high gravity, or elevation 448 feet, and the Crystal Springs that of low gravity of 378 feet. The normal diversion through the Crystal Springs and headworks galleries is supplemented by pumped water in both instances, the headworks plant consists of a steam driven compressor and the Crystal Springs plant of a motor driven compressor and in both cases numerous wells are blown by air, thus supplementing the normal flow through the galleries.

By far the greatest portion of the City is served by gravity and low lift pumps. This amounts to 114 square miles in the main portion of the City. This supply as above mentioned is double ended from the Los Angeles Aqueduct and the Los Angeles River, being supplemented by three pumping plants in the South central portion of the City located along Slauson Avenue and known as the Compton, Figueroa and Manhattan Pumping Plants.

These three plants derive their supply from wells. The wells at the Compton and Figueroa Plants are pumped by air, the plants proper being steam operated and consist of cross compound pumping engines and Laidlow-Dunn-Gordon Compressors. The Manhattan Plant derives its power from a Diesel engine driving a generator which furnishes power for pumping wells by motor driven deep well pumps discharging into a sump, the main pump in this plant being 2 DeLaval single stage pumps connected in series and driven in tandem.

At all three of the above mentioned plants the water is pumped directly into the mains against the head of the Buena Vista Reservoir at an average head of 235 feet. As there are no reservoir sites in the southern part of the City, in addition to acting as a supplemental supply, these plants have the added advantage of kicking back on the entire system thereby raising the hydraulic gradient and enabling us to maintain a normal service and pressure, which could only otherwise be obtained by the expenditure of an enormous amount of money in the laying of many miles of large trunk lines.

The Harbor District comprising Wilmington and San Pedro, an area of approximately six square miles, is supplied entirely by pumped water. The Wilmington Pumping Plant, being similar to the Figueroa Plant, is the present supply. At the present time, however, the Department is installing at Lomita, a new Diesel

Plant, being the identical duplicate of the present Manhattan Plant above referred to.

One of the fastest growing sections of the entire City is that of the hill areas or the pumped zone. This particular district consists of the Hollywood Foothills, the north central section of the City, and the entire northeast portion.

As before mentioned elsewhere in this paper, you will note that the Hollywood Foothills Section will derive its supply entirely from gravity, where, at the present time it is served by pumps, and the reader may wonder why the other sections lying to the east of this area are not also served by gravity as Aqueduct water is brought into the City at elevations far above those lying in the pumped zones. However, the entry of this water into the City proper lies to the extreme west limits and it would not be economical from a construction and operating standpoint to attempt to lay large trunk lines from the western portion of the City to this eastern pumped section, due to the fact that these trunk lines would traverse a most highly developed section of the City and the cost would be prohibitive.

The most complicated area that is served in the various pumped zones of the City's system is that of the 613 elevation. This particular zone may be represented as appearing very much like the human hand. The larger area would be represented by the palm with four fingers protruding therefrom, while in between these fingers are areas of both higher and lower elevations. Consequently the entire zone presents a complex and ragged unit.

The area as above represented, amounts to 26 per cent of the total territory served by pumping plants. Plans are now under way which will be perfected during the winter to relieve approximately 40 per cent of this territory by the substitution of gravity water, the source of which will be the new Hollywood Reservoir.

Out of the 30 square miles of pumped service there are five plants serving 12 square miles, of which all the water is re-pumped, with the exception of one plant, the San Pedro Hill service in the Harbor District, the other plants serve the north central and northeast portions of the City.

Within the main portion of the City and the Harbor District there are twenty-one pumping plants. Of these five are steam, fourteen electric and two Diesel engine. The waters of many of these plants are inter-mingled to such an extent that it is impossible

TABLE 1

Costs of operation for various types of pumping plants in the city of Los Angeles

Fiscal year 1923–1924

PLANT	PUMPING HEAD	TYPE OF PLANT	TOTAL CUBIC FEET PUMPED IN YEAR	TOTAL CHARGEABLE		OPERATING AND MAINTENANCE		RATIO OF OPERATING TO TOTAL CHARGEABLE
				Cost per million gallons per 100 feet raised	Cost per 100 cubic feet per 100 feet raised	Cost per million gallons per 100 feet raised	Cost per 100 cubic feet per 100 feet raised	
	feet							*per cent*
Buena Vista	250	Steam	439,305,200	$9.2847	$0.00676	$7.327	$0.0053	79
Compton	236—total (81 suction)	Steam	101,804,390	15.375	0.0115	12.2458	0.00916	80
Figueroa	235—total (62 suction)	Steam	209,326,200	10.955	0.0082	9.2275	0.0069	84
Wilmington	246—total (77 suction)	Steam Electricity Booster	332,054,500	11.266	0.0084	9.49	0.0071	84
Mean	239			12.532	0.0094	10.3211	0.0077	
Mead	188	Electricity	18,615,100	7.869	0.00588	6.221	0.00465	79
Riverside:		Electricity						
a. Garvanza	296	Electricity	233,340,300	*	*	5.491	0.004108	
b. Edendale	323	Electricity	69,603,260			5.033	0.003765	
Seventh Street	106	Electricity	135,824,000	†	†	7.273	0.00544	
Mean	228					6.005	0.00449	

* Riverside Plant put in operation during 1923–24.

† Seventh Street Plant has temporary building.

to segregate and obtain unit costs per acre of the areas actually served by each individual plant.

The accompanying table shows the cost on a few of the typical plants in the system. Under the column "Total chargeable" is included depreciation on equipment at 4 per cent, buildings at 2 per cent, interest on investment at 6 per cent and annual maintenance and operation for the year 1923–1924.

In order to illustrate the problem in connection with pumped water in the main portion of the City of Los Angeles and the Harbor District, it might be well to state that the mean daily average domestic consumption for the fiscal year ending June 30, 1924 amounted to 105,000,000 gallons per day, while the daily average amount of water pumped for the corresponding period was 56,500,000 gallons per day.

THE SENSITIVITY OF THE ORTHO-TOLIDINE AND STARCH-IODIDE TESTS FOR FREE CHLORINE

By A. M. Buswell[1] and C. S. Boruff[2]

Rapid growth in the field of chlorination of waters, swimming pools and sterilization of sewage plant effluents brought about the need of a quantitative test for small amounts of excess chlorine. Ellms and Hauser (1) have introduced and standardized the ortho-tolidine test. By using this test Wolman and Enslow (2) have made it possible to determine the chlorine absorption of any water in an hour's time. Previous to their work it was a matter of adding chlorine and then plating samples to determine the efficiency of the treatment. This procedure takes twenty-four hours or more.

The ortho-tolidine test is a good plant control test, but in order that it may be used in refined studies the authors have felt that it should be further studied. Ellms and Hauser (3) studied the ortho-tolidine test as to its sensitivity and the action upon it of iron, manganese and nitrites. The authors have continued the work opened up by Ellms and Hauser together with similar studies on the starch iodide test.

EXPERIMENTAL

A. Ortho-tolidine test

1. Checking of standards

In testing the validity of the O. T. standards the authors prepared chlorine water by bubbling washed chlorine into water redistilled from $KMnO_4$. The chlorine gas was prepared by action of HCl on $KMnO_4$. This chlorine water was diluted, well mixed and placed in a small carboy painted black and protected to keep out light. An all glass syphon from the carboy lead to a standardized burette from which definite amounts of the chlorine water could be drawn.

This chlorine water after standing at least two days was stand-

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arized against thiosulfate solutions which had previously been standardized against solutions of dichromate of definite strengths. Two potassium dichromate solutions were used. One was the C. P. product of the Central Scientific Company and the other the C. P. product of Baker. Both were dried at 105°C. before weighing. Both were used in standardizing the thiosulfate solutions. One standard dichromate solution was prepared by taking 282 cc. of N/10 dichromate and diluting it to 1 liter. Each cubic centimeter of this solution was equivalent to 1 gram per liter of Cl or 1000 p.p.m. Solutions of one-half and one-tenth of this strength were prepared so that there were three standard dichromate solutions.

In solution No. 1—1 cc. was equivalent to 1.0 mg. of Cl
In solution No. 2—1 cc. was equivalent to 0.5 mg. of Cl
In solution No. 3—1 cc. was equivalent to 0.1 mg. of Cl

These dichromate solutions were titrated against thiosulfate solutions of approximately the same strength, which in turn were used to determine the strength of the chlorine water. In all titrations the method of iodine displacement from KI in acid solution was used. A solution of starch was added near the end of the titration to act as the indicator. In all titrations between dichromate and thio and between thio and the chlorine water the following proportions were used:

200 cc. of redistilled water
6 cc. of fresh KI solution, I free (1 cc. = 0.5 gram)
5 cc. of concentrated C. P. HCl (Cl free)
5 cc. of fresh starch solution (1 gram per 200 cc.)

In all titrations the KI and the HCl were added to the water before the chlorine water was added, in order that the chlorine would be picked up at once and the I thrown out before any Cl had time to escape. Standardized apparatus and quantitative methods were used throughout.

In the first experiments all three strengths of thio were used in standardizing the chlorine water. Later only the two stronger solutions were used, because with the weaker it was not only very difficult to check titrations but none seemed to check very closely with the other two solutions. The two stronger solutions, however, checked very closely when 30 to 50 cc. of the chlorine water was used. The final results of a characteristic run using all three solutions is found in table 1.

Having prepared a standard solution of chlorine water the next step was to make definite dilutions to give 0.04, 0.06, 0.08, etc., p.p.m. of Cl and to check these solutions against the ortho-tolidine standards. Such a procedure was followed, but, at first, all chlorine water tubes read lower than the standards. Muer and Hale (4) had difficulty in checking the ortho-tolidine standard on account of losing chlorine when the standard chlorine water was diluted for testing. They state that it was probably due to loss into the air, to adsorption by the glass, or absorption by the dilution water. The authors experienced the same difficulty. After many experiments the assumption that H_2O distilled from $KMnO_4$ had no Cl capacity was found to be a faulty one. Water freshly redistilled from $KMnO_4$ had a chlorine capacity sufficient to throw off all results. To overcome this error chlorine water was added to the dilution water until after thirty minutes it gave a slight test (0.005

TABLE 1

Standardization of chlorine water

STRENGTH OF THIO GRAMS OF Cl PER LITER		STRENGTH OF Cl – H_2O GRAMS OF Cl PER LITER
Approximate	Actual	
1.0	0.934	0 0439
0.5	0.45	0.0438
0.1	0.0893	0.0424

p.p.m.). This solution was allowed to stand at least four hours before proceeding. If a tested portion still contained a trace of chlorine, distilled water was added until the point was reached where the color disappeared in a test portion, in other words until a tested portion showed no excess chlorine. Upon using water treated thus in diluting the standard chlorine water, colors were obtained which checked Ellms and Hauser's dichromate standards. Checks were made only from 0.02 to 0.2 p.p.m. as the lower range is the only one used to any extent in control of chlorine in water treatment. The depth of color in the tubes was read and comparisons made with the aid of the "mirrow camera," so placed in the window that good light was accessible and no shadows were thrown on the mirrors.

The dichromate and copper-sulfate standards as outlined in Ellms and Hauser's original work were used in half portions, and were

made up to 50 cc. instead of 100 in order that 50 cc. Nessler tubes might be used instead of the older 100 cc. type. Instead of using 1 cc. of the standard ortho-tolidine solution, 0.5 cc. was used per 50 cc. This change was made on account of the general shifting in all colorimetric determinations to use 50 cc. Nessler tubes.

Since Muer and Hale (4) have brought up the question as to the exactness of the ortho-tolidine standards, transmittancy curves have been run on the chlorine ortho-tolidine colors as well as curves on the standards. These curves bear out the fact that the ortho-tolidine and the standard tube colors are not true spectral matches. Therefore the quantities required to give an apparent match when plotted would not form a straight line, but one would expect, as Muer and Hale state, that the quantities of dichromate as used in the standards when plotted would form a smooth curve.

This preliminary study of the chlorine ortho-tolidine color with the spectrophotometer opens up a field for further investigations which the authors intend to pursue. From investigations so far we have reason to hope that standards can be prepared which will give a more exact spectral match.

Even though the ortho-tolidine standards do not represent the true numerical content of chlorine, our conclusions as to the effect of various substances on the chlorine-ortho-tolidine color are correct, since both the blanks and the tubes to which reagents were added were referred to the same standards.

2. Time and persistency

Graphs were made of the time of development and of duration of the ortho-tolidine color in chlorine water (see fig. 1). These investigations confirmed the work of some investigators, but differed slightly with statements of Ellms and Hauser, who claim that the color comes to its maximum in three minutes and lasts thirty. The authors found it more accurate to read the color after five rather than after three minutes. The stronger the chlorine water the quicker the ortho-tolidine color comes to its maximum and the longer it lasts. Shaking and inverting the tubes many times after adding the ortho-tolidine reagent hastened the reaction. In making the determinations for the graph the tubes were inverted only twice to mix the reagent and the chlorine solution.

3. Effect of change in temperature

As the ortho-tolidine test depends on an oxidation process the depth of color varied directly as the temperature, as shown in table 2. Fortunately, however, there was no noticeable change in the color in the range of temperatures most commonly associated with water treatment. The same chlorine water was used throughout all the tests of that particular strength. The temperature of the water

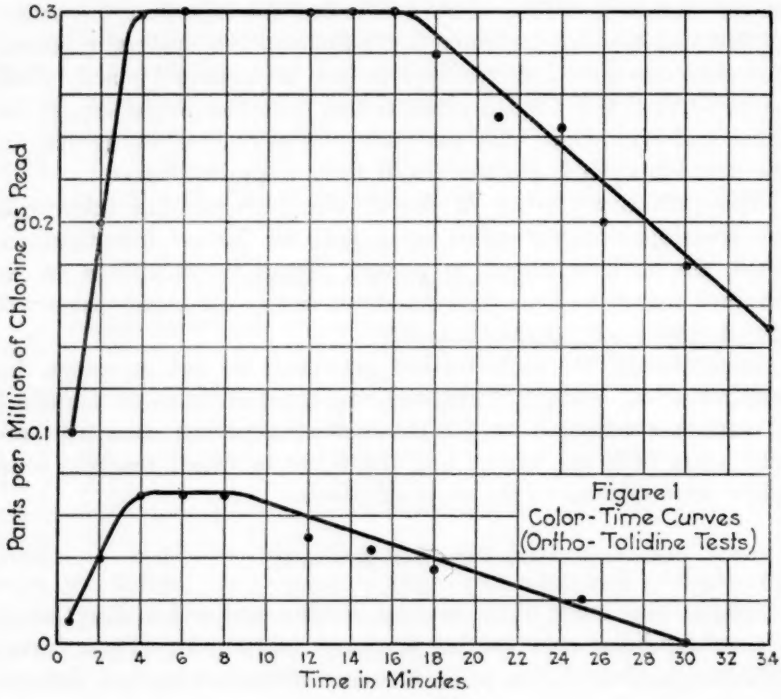

FIG. 1

was changed by transferring the flasks from one bath to another. The temperatures were taken after the water has been placed in the Nessler tube and the ortho-tolidine reagent added.

4. Effect of change in pH

To investigate the effect on the ortho-tolidine of change in pH definite amounts of dilute acid solutions were added to the Nessler tubes of chlorine water. The pH of the chlorine water was deter-

mined by adding the same amount of acid to the tubes of distilled water and determining the pH of these colorimetrically. It was impossible to determine the pH of the chlorine water directly as the chlorine decolorized the indicators used. The hydrogen electrode method could not be used for the chlorine would attack the platinum electrode. The acidity due to the HCl and the HOCl from

TABLE 2

Temperature effects on ortho-tolidine test

TEMPERATURE	Cl-H_2O		TIME OF READING AFTER ADDING REAGENTS
	Added	Found	
°C.	p.p.m.	p.p.m.	minutes
7	0.05	0.03	5
7	0.5	0.04	10
10	0.05	0.04	5
15	0.05	0.04	5
20	0.05	0.05	5
22	0.05	0.05	3
25	0.05	0.05	3
30	0.05	0.05	3
35	0.05	0.05	3
40	0.05	0.06	15 seconds
45	0.05	0.07	15 seconds
50	0.05	0.08	15 seconds
10	0.1	0.04	5
15	0.1	0.06	5
17	0.1	0.1	3
20	0.1	0.1	3
22	0.1	0.1	3
35	0.1	0.15	3
45	0.1	0.2	15 seconds
55	0.1	0.2	15 seconds

the reaction of Cl_2 in H_2O was neglected as this would be very small in the dilute chlorine water. One would expect the equilibrium of chlorine in water,

$$Cl_2 + H_2O \rightleftarrows HOCl + HCl$$

to be affected by change in pH. It was found that small amounts of acids had no appreciable effect on the equilibrium as found in low concentrations of chlorine water. When sufficient amounts of

the acids were added to the chlorine water to give it a pH of 3 or less, that is a pH of 2.5–2.0, the color of the ortho-tolidine test gradually decreased. The three acids used, namely, HCl, H_2SO_4, and HNO_3 had no effect on the test as long as the solution had a pH of more than 3.

Carbonates and bicarbonates had no effect as long as the pH was less than 8. As the solution became more basic a rapid decrease in color occurred. The same effect was noted when NaOH was used.

This color change action of the ortho-tolidine may be explained in two ways The ortho-tolidine undoubtedly acts as an indicator having a very wide range and acting between the pH of 3 and 8. Furthermore, due to common hydrogen ion effect on the right side of the equation, moderate concentrations of acids would force the chlorine water equilibrium to the left. If it is the HOCl that oxidizes the ortho-tolidine and gives the color, which undoubtedly is the case, the color would naturally be reduced if the concentration of the HOCl were reduced. High concentrations of bases and carbonates would tend to remove the HOCl and HCl on the right hand side of the equilibrium. This would be followed by a general shifting to the right in which more HOCl and HCl would be formed, which would again be removed by the bases and carbonates if these were present in sufficient amounts. These shiftings would lower the final color of the test. It is well to note that low concentrations of acids, bases, carbonates, and bicarbonates had no effect on the chlorine determination.

5. Effect of certain organic compounds

A number of organic compounds were added to chlorine water of a strength of 0.05 p.p.m. In each case the organic solution was added to the 50 cc. tube of chlorine water and then thoroughly mixed and ten minutes of time given for any reaction that might take place before the ortho-tolidine reagent was added. The results are tabulated in table 3. The strength of the gelatin solution used in the one case gave approximately the concentration of nitrogen found in sewage, namely about 40 to 50 p.p.m. In the weaker solution it gave up to 1.0 p.p.m., which is a high average amount found in drinking water. It will be noted that most organic compounds reacted with the chlorine water removing part of it. It is well to note that in no case tested did the organic compound give

darker colors with the ortho-tolidine. As is brought out in the tests with gelatin the reactions took place in proportion to the concentration of the reacting substances.

TABLE 3

Effect of organic compounds on tests

COMPOUNDS USED	AMOUNT USED	$Cl\text{-}H_2O$ ADDED	CHLORINE FOUND	
			Ortho-tolidine	Starch-iodine
		p.p.m.	*p.p.m.*	*p.p.m.*
Starch	50 p.p.m.	0.05	0	Slightly lighter (−)
Uric acid	50 p.p.m.	0.05	0	0
Acetic	1 cc. 5 per cent by volume	0.05	0.05	0.05
Phenol	1 cc. 5 per cent by volume	0.05	0	Lighter (−)
Acetone	1 cc. 5 per cent by volume	0.05	0.04	Slightly lighter (−)
Methyl alcohol	1 cc. 5 per cent by volume	0.05	0.04	Slightly lighter (−)
Sugar (cane)	100 p.p.m.	0.05	0.05	0.05
Urea	100 p.p.m.	0.05	0.05	0.05
Gelatin*	50 p.p.m. of N	0.05	0	0
	40 p.p.m. of N	0.05	0.01	Trace
	20 p.p.m. of N	0.05	0.02	–
	1.5 p.p.m. of N	0.05	0.03	–
	1.2	0.05	0.03	–
	1.0	0.05	0.03	–
	0.8	0.05	0.03	–
	0.6	0.05	0.04	–
	0.4	0.05	0.04	–
	0.2	0.05	0.04	–
	1.0	0.1	0.06	–
	0.8	0.1	0.07	–
	0.6	0.1	0.07	–
	0.4	0.1	0.08	–
	0.2	0.1	0.08	–

* Gelatin was calculated as 17.97 per cent N (Mathews (12)).

6. Effect of certain ions and salts

Standard solutions of possible interfering ions were made up, and definite amounts added to the 50 cc. Nessler tubes of chlorine

TABLE 4

Effect of certain compounds on the ortho-tolidine and starch—iodide tests

COMPOUND USED	AMOUNT OF COMPOUND	Cl-H_2O	Cl-H_2O FOUND	
			By ortho-tolidine	By starch-iodine (compared with amount added)
	p.p.m.		*p.p.m.*	*p.p.m.*
$Al(NO_3)_3$	50	0.1	0.1	0.1
$Al_2(SO_4)_3$	50	0.1	0.1	0.1
$BaCO_3$	50	0.1	0.1	0.1
$Ba(OH)_2$	50	0.1	0.1	0.1
$BaSO_4$	50	0.1	0.1	0.1
$Ba(NO_3)_2$	50	0.1	0.1	0.1
$BaCl_2$	50	0.1	0.1	0.1
$BaSO_3$	50	0.1	0.1	0.1
$Ca(NO_3)_2$	50	0.1	0.1	0.1
$CaSO_4$	500	0.1	0.1	0.1
$CaCO_3$	500	0.1	0.1	0.1
$CaCl_2$	500	0.1	0.1	0.1
NH_4Cl	500	0.1	0.1	0.1
$(NH_4)_2SO_4$	500	0.1	0.1	0.1
$(NH_4)_2CO_3$	500	0.1	0.06	–
NH_4NO_3	500	0.1	0.1	0.1
NaOH	50	0.1	0.1	0.1
KCH	50	0.1	0.1	0.1
KOH	500	0.1	0.06	–
NaOH	500	0.1	0.06	–
$FeCO_3$	5	0.1	0.05	–
$FeSO_4$	5	0.1	0.05	–
$FeCl_2$	5	0.1	0.05	–
$FeCO_3$	5	0.04	0	0
$FeSO_4$	5	0.04	0	0
$FeCl_2$	5	0.04	0	0
(For further consideration of Fe see table 5)				
$MgCO_3$	500	0.1	0.1	0.1
$MgSO_4$	500	0.1	0.1	0.1
$Mg(NO_3)_2$	500	0.1	0.1	0.1
$MgCl_2$	500	0.1	0.1	0.1
Na_2CO_3	25	0.1	0.1	0.1
$NaHCO_3$	25	0.1	0.1	0.1
Na_2CO_3	500	0.1	0.06	–
$NaHCO_3$	500	0.1	0.06	–
$NaNO_2$	2	0.04	0.04	+
$NaNO_2$	5	0.04	+	++
$NaNO_2$	12	0.04	++	+++

TABLE 4—*Continued*

COMPOUND USED	AMOUNT OF COMPOUND	Cl-H_2O	Cl-H_2O FOUND	
			By ortho-tolidine	By starch-iodine (compared with amount added)
	p.p.m.		*p.p.m.*	*p.p.m.*
$NaNO_2$	25	0.04	+++	++++
NaCl	500	0.04	0.1	0.1
Na_2CaO_2	10	0.1	0.1	0.1
Na_2SO_4	500	0.1	0.1	0.1
$MnSO_4$	25	0.1	0.1	+
$Mn(NO_3)_2$	25	0.1	0.1	+
$MnCl_2$	25	0.1	0.1	+

water. Chlorine waters of 0.04 and 0.1 p.p.m. were used in various tests as shown in table 4. It will be noted that only two ions interfered with the ortho-tolidine test. They were iron and nitrites. Alkalies in high concentrations also affected the sensitivity of the test. The author found that manganese up to 11 p.p.m. had no effect on the depth of the ortho-tolidine color. This is contrary to work carried out by the original investigators (3).

The effect of iron upon the ortho-tolidine test was studied very carefully. Ellms and Hauser state that iron interferes with the test. Due to oxidation of the iron by the chlorine water, which in turn was reduced in concentration, ferrous compounds lowered the final color readings. See table 4. Ferric compounds, however, gave a deeper color to the chlorine water, as is shown in table 5. When a definite amount of the standard iron solution was added to distilled water it gave a yellow color, which differed so slightly from the ortho-tolidine standards that comparative readings could be made without much error. If two 50 cc. samples of 0.05 p.p.m chlorine water were taken and to one was added 2 p.p.m. of Fe as $FeCl_3$ and then both were treated with the ortho-tolidine reagent the one sample containing the Fe read higher than the one containing no Fe. When 2 p.p.m. of Fe as $FeCl_3$ were added to distilled water and compared with dichromate standards it read approximately 0.04 p.p.m. of chlorine. Hence in the tube containing the 0.05 p.p.m. of Cl, and Fe of a color equivalent to 0.04 p.p.m. of Cl, there was the combined effect of the two depths of color which should give a reading of 0.09. When this tube containing the chlorine and the

Fe was read in comparison with the dichromate standards it read 0.09 p.p.m. as predicted. This was checked many times using different amounts of Fe with different strengths of chlorine water. $Fe(NO_3)_3$ was also used as the source of the Fe. It acted in the same way as did the $FeCl_3$. Hence the greater depth of color in the chlorine water tubes which contained Fe was due to the color of the Fe solution itself, and not to any oxidizing effect of the Fe on the ortho-tolidine. Ferric salts are oxidizing agents and one might expect them to act on the ortho-tolidine as they do act on the starch-iodine test. $Fe_2(SO_4)_3$ figured as 6 p.p.m. of Fe had no such effect. It cannot be said that ferric iron interferes chemically with this test, but due to its yellow color it does interfere physically.

TABLE 5

Effect of ferric iron on the ortho-tolidine and starch—iodide test

COMPOUND USED	Fe ADDED	$Cl-H_2O$ ADDED	EFFECTS	
			Ortho-tolidine	Starch-iodide
	p.p.m.	*p.p.m.*		
$Fe_2(SO_4)_3$.....	0.2–0.6	0.05	No effect	At 0.6 test darker (+)
$FeCl_3$.....	0.2–1.0	0.05	No effect	At 0.6 test darker (+)
$FeCl_3$.....	1.4	0.05	Slightly darker	Much darker (++)
$FeCl_3$.....	2.0	0.05	Darker (+)	Much darker (++)
$FeCl_3$.....	4.0	0.05	Darker (++)	Much darker (+++)
$Fe(NO_3)_3$.....	0.2–1.0	0.05	No effect	At 0.6 test slightly darker
$Fe(NO_3)_3$.....	1.4–3.0	0.05	Darker (+)	Much darker (++)

* Fe solutions prepared so that 0.5 cc. = 1 p.p.m. of Fe in 50 cc. H_2O.

A given amount of Fe as $FeCl_3$ does not interfere as much as does the same amount of Fe as $Fe(NO_3)_3$ the color depth of the compounds being the responsible factor. Fe in a concentration up to 1 p.p.m. when as $FeCl_3$ or $Fe(NO_3)_3$ had no effect on the test. When these salts are added above these concentrations, a gradual increase in depth of color was noted due to the color of these iron solutions.

The effect on the ortho-tolidine test of nitrites was tested by first adding definite amounts of a $NaNO_2$ solution to 50 cc. Nessler tubes of chlorine water. After giving this solution 10 minutes for reaction, it was tested for excess chlorine by adding the ortho-tolidine reagent. In the tubes containing 2 to 6 p.p.m. of nitrite

N, the standard solution was merely measured by pipettes. In the lower concentrations the same amount of dilute nitrite solution which had been added to the 50 cc. of chlorine water was added to a 50 cc. portion of distilled water free from nitrites. The nitrite concentration was determined by running the standard colorimetric nitrite test as outlined in Standard Methods of Water Analysis, page 18.

TABLE 6

Effect of nitrites on the tests

N as NO_2	Cl-H_2O	Effect* (Cl found)	
		Ortho-tolidine	Starch-iodide
p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*
6.0	0.05	+++	+++++
4.0	0.05	++	++++
2.0	0.05	+	+++
0.6	0.1	0	+++
0.5	0.1	0	
0.3	0.1	0	+++
0.2	0.1	0	
0.15	0.1	0	+++
0.10	0.1	0	
0.06	0.1	0	
0.05	0.1	0	
0.03	0.1	0	++
0.025	0.1	0	
0.015	0.1	0.02	+
0.005	0.1	0.1	0.1 O.K.
0.002	0.1	0.1	0.1 O.K.

* (+) indicates deeper color than standard; (−) indicates lighter color than standard.

Ellms and Hauser state that nitrites interfere with the ortho-tolidine test. Investigations by the authors brought out the fact that nitrites in high concentrations (2 to 6 p.p.m.) do give a darker color to the ortho-tolidine test. In lower concentrations, on the contrary (0.6 to 0.005 p.p.m.) nitrites caused a reduction in color. In concentrations from 0.005 to zero it had no effect. See table 6. In a solution of chlorine water containing nitrite nitrogen, among other equilibria the following two may be present.

$$N^{+++} + 2\,Cl \rightleftarrows 2\,Cl^{-} + N^{+++++}$$

$$N^{+++} + \quad Cl^{-} \rightleftarrows Cl \; + N^{++}$$

Kolthoff (8) and others (9, 10, 11) state that certain salts, some of which are found in waters, have the property of changing the pH of their solutions more than the calculated amount. They found that chlorides and sulfates had more effect than other negative ions, so in order to get the maximum effect both were used in these tests. Al, Ca, K, NH_4, Na and Mg sulfate and chloride solutions were tested in concentrations of 50 p.p.m. as to their effect on the ortho-tolidine color in chlorine water of a strength of 0.05 p.p.m. No difference in depth or tint was noted in any of the tubes when they were compared with one another or with the pure chlorine water tube.

B. Starch-iodide test

1. Procedure

The starch-iodide test for excess halogens has been known for some time, but there seems to be a great difference of opinions as to its sensitivities and applicability. Kolthoff (8) says that acids, Fe and nitrites increase the color and that organic matter decreases it. Treadwell and Hall (13) as well as other analytical chemists, say that the iodide ion and acid concentrations have a great deal to do with the reaction.

In this test as in the ortho-tolidine method the investigations were carried out in 50 cc. Nessler tubes reading comparatively the depth of color with the aid of the "camera." As there are no colorimetric standards for this test, all determinations are marked (+) for a slightly darker color than the standard. A (++) indicates a color slightly lighter than the standard. A large amount of weak chlorine water was prepared which had a strength of about 0.1 p.p.m. free Cl. Tests were made by taking 50 cc. portions of this water and adding varying amounts of KI, acids and starch. The KI and the acid were added immediately after the tubes were filled to the mark with the standard chlorine water. This was shaken and inverted 3 to 5 times to insure mixing. After about 2 minutes the starch solution was added. The color came up at once on shaking and remained constant for from 5 to 8 minutes after which time it gradually gained in depth. A fresh solution of KI which was I free was prepared each time in small amounts, so that 1 cc. contained 0.5 gram of KI. C. P. Concentrated HCl which was Cl free was used as the acid. The starch solution was prepared by dis-

solving 1 gram of Soluble Starch Merck (according to Linter) in 200 cc. of distilled water. This solution was made up each day.

The deepest and most sensitive test was obtained when 0.75 gram of KI, 2 cc. of C. P. Concentrated HCl and 1 to 1.5 cc. of starch solution was used. By using these proportions at 23°C., 0.005 p.p.m. of excess Cl could be detected.

2. Effect of change in temperature

As the starch-iodide, like the ortho-tolidine, test is in principle an oxidation process an investigation identical with that used in the study of the effect of change of temperature on the ortho-tolidine test was made. It was noted that as the temperature was

TABLE 7

Temperature effects on starch—iodide test

TEMPERATURE	COMPARATIVE DEPTH READINGS OF COLOR AFTER 1 MINUTE
°C.	
10	+++
15	++
20	+
23	Taken as the standard
30	−
35	−−−
40	−−−
45	−−−

* Cl-H_2O of 0.5 and 0.2 p.p.m. were used.

(+) indicates deeper color, (−) indicates lighter color.

lowered the color became deeper. For the tabulated results see table 7. Smaller amounts of chlorine could be detected at lower than at higher temperatures. In other words sensitivity increased inversely with the temperature. In testing for excess Cl in waters of low temperature this method would be exceptionally good. The test made at 23°C. was taken as the standard. Colors deeper than this were marked (+) and those lighter (−).

3. Effect of change in pH

In studying the effect of change in pH on the starch-iodide test it was found that the acid concentration given to 50 cc. of distilled water by adding 2 cc. of C. P. concentrated HCl was the best hydro-

gen ion concentration for this test. Higher concentrations gave a variable purple-blue color. Carbonates, bicarbonates and alkalies affected the test only to the extent in which they neutralized part of the acid.

4. Effect of organic compounds

The effect of a number of organic compounds on the starch-iodide test was investigated. In these determinations the same procedure was used as in the analogous investigations with the ortho-tolidine test. One gelatin solution used gave to the tube concentrations of N of 40 to 50 p.p.m. which is an average N content of sewage. The other gave concentrations to 1 p.p.m. of N which is the range of concentrations found in drinking water. The results are tabulated with the ortho-tolidine results in table 3. As in the study with the ortho-tolidine it was found that chlorine was utilized by the organic compounds, thus lowering the amount of excess left in solution.

5. Effect of certain ions and salts

As with the ortho-tolidine method, tests were made as to the effect on the starch-iodide test of certain salts found in potable waters. The same procedure was used as in the study of the ortho-tolidine test. The results are tabulated in table 4. Of the ions tested iron, manganese and nitrites were the only ones to interfere. The action of iron in iodine tirations has been studied extensively. Its action in dissolved oxygen determinations has been studied by Buswell and Gallaher (5).

Manganous compounds when present in concentrations above 25 p.p.m. figured in terms of Mn, slightly darken the final test. The effect of 25 p.p.m. of Mn was about equivalent to the darkening effect of 0.6 p.p.m. of Fe. Since C. P. manganous compounds would not have this large a percentage of iron in them, the effect must be attributed to some trace of manganic ion in the compounds used. Two cubic centimeters of standard $MnSO_4$ solution, as used in dissolved oxygen determinations, which had stood for a year, displaced from KI a very small amount of iodine as noted in a 50 cc. Nessler tube by the aid of a "camera." The amount displaced, however, was not enough to be titratable. The effect of nitrites on the starch-iodide test is well known. See table 6. In determining dissolved oxygen in water nitrites must be destroyed before the oxygen can be determined (7).

The effect on the starch-iodide test of certain salts which according to Kolthoff (8) and others (9, 10, 11) change the pH of their solutions was also investigated by adding 50 p.p.m. of the chlorides and sulfates of these compounds to tubes of 0.05 p.p.m. of free chlorine. It was found that the chlorides and sulfates of Al, Ca, K, NH_4, Na, and Mg had no effect on the test. In other words the pH change due to these salts was not sufficient to make any difference in the test.

6. Difficulties in standardization

In order that the starch-iodide test should become of importance in quantitatively determining the amount of chlorine in water it would be necessary to standardize it and prepare colorimetric tubes by which comparisons with unknowns could be made. This might be done by using different dyes as did Adams (6), or by mixing colored inorganic solutions such as $Cu(NO_3)_2$ and $CO(NO_3)_2$, which give a fairly good standard for this test. The main difficulty in the standardization of this test lies in the fact that it gives a colloidal solution. It is very difficult to prepare colloidal solution standards. The authors attempted to run a number of transmittancy curves on this test but all were without satisfactory results. Iron and manganese interferences present another problem. Unlike the ortho-tolidine test small amounts interfere, and as these two cations are common in waters, a great deal of work will be necessary if the test is to be standardized so that it can be used in any water.

CONCLUSIONS AND RECOMMENDATIONS

In a comparative analysis of the ortho-tolidine and the starch-iodide tests there are many things to be taken into consideration. The tests are equally sensitive, each giving a positive test for 0.005 p.p.m. of excess Cl in a 50 cc. Nessler tube at room temperature.

In the ortho-tolidine method, iron when present as the chloride or nitrate above 1 p.p.m. gives a yellow colored solution and interferes with quantitative determinations of excess Cl. Nitrites in low concentrations, as found in potable waters, do not interfere with the ortho-tolidine test for excess chlorine because they are oxidized by the chlorine added. The compounds formed have no effect on the ortho-tolidine reagent.

Nitrites above 1 p.p.m. (in terms of N) do give a slight color with the ortho-tolidine reagent. This color becomes darker with in-

creasing concentrations of the nitrites then finally fades out. In the presence of free chlorine these nitrites are oxidized to an extent that they do not interfere.

As long as the water has a pH between 3 and 8 there is no effect on the ortho-tolidine test. If the water is more basic than pH 8, acid should be added to the water or to the reagent to bring it within the pH 3 to 8 range.

The ortho-tolidine test becomes less sensitive in lower temperatures.

Oxidized organic compounds have no effect on the test.

In the starch-iodide test, small amounts of iron do interfere. Nitrites in low concentrations affect the test. Manganese also interferes.

The hydrogen ion concentration, as well, is an important factor in the starch-iodide test. The most sensitive concentration for this test is that given by 2 cc. of concentrated HCl in 50 cc. of water. Higher concentrations give a purple-blue combination and lower concentrations a lighter blue which is not as sensitive.

The starch-iodide test becomes more sensitive at lower temperatures. Oxidized organic compounds do not interfere.

The authors recommend the ortho-tolidine test for excess chlorine in water, using Ellms and Hauser's standards in half portions in order that 50 cc. Nessler tubes may be employed

In waters where the temperature runs low the starch-iodide test should be used as it becomes more sensitive under such conditions and the ortho-tolidine less sensitive. The use of the ortho-tolidine method in waters of low temperatures with the regular standards would lead to overdosing, with the consequent odors and tastes.

The starch-iodide test takes three solutions; Concentrated HCl, KI, and a starch solution, all of which soon deteriorate or change in such a way that they cannot be used. Free Cl in the HCl, free I in the KI, or molds in the starch solution will render the results unreliable. The ortho-tolidine reagent, on the other hand, is easily prepared and keeps well. If the water is colored or if the iron content is high, the standards must be prepared to make the corrections. The ortho-tolidine test is much more applicable as a quantitative test than is the starch-iodide, not only because the reagent is more stable and the test less affected by certain interfering substances, but also because of the simplicity of the method, a factor worthy of note when considering a commercial or plant control test.

DISCUSSION

LINN H. ENSLOW:[3] The publication of the results of the study of the ortho-tolidine method compared with the starch-iodide method of residual chlorine determinations will do much toward clearing up many debatable points as to the relative merits of the two methods under variable conditions. Such a study as by Dr. Buswell and Mr. Boruff has been needed for some time and this contribution to the water-works and sewage-disposal field is a timely one. The findings will be materially appreciated by those responsible for plant control and purification supervision.

From the results one can but conclude, as the authors have done, that the ortho-tolidine test under all practical conditions is reliable and in all points superior to the more cumbersome starch-iodide method.

The matter of the greater accuracy of the latter method at temperatures lower than 17°C. (62.6°F.) is of relatively little importance in the routine control tests using ortho-tolidine. The writer has found it necessary to allow a longer period of contact between ortho-tolidine solution and the water sample when the temperature is below 20°C. The procedure at such times should be to warm the mixture *gently* or allow it to stand until the temperature is above 20 deg. before comparing with the standards.

The conclusions relative to the effect produced by the presence of iron salts agree with results obtained in actual plant control. The effluent from a slow-sand filter plant contained 7 p.p.m. soluble iron, which was most probably in the form of ferrous carbonate. Chlorine applied failed to produce a residual chlorine test with ortho-tolidine, until all of the organic and ferrous iron demand for chlorine had been satisfied. At this point a slight increase in chlorine applied produced a characteristic residual chlorine color. It was concluded from this experience that at least 6 p.p.m. of oxidized iron (Fe) produced no false color when acidified with the concentration of the hydrochloric acid in the ortho-tolidine solution, nor did it produce a

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false residual chlorine color with ortho-tolidine. In another instance a well water containing 10 p.p.m. iron failed to produce a color with ortho-tolidine.

The results obtained from solutions containing manganese are especially interesting in that they indicate that this metal does not produce with ortho-tolidine a color reaction when present in concentrations of less than 11 p.p.m. It has always been the opinion of most persons familiar with the work of Ellms and Hauser that manganese salts would produce a color interfering with the ortho-tolidine test. Although the writer has had no experience with manganese bearing waters, others have reported from plant experience that ortho-tolidine is an excellent indicator of manganese when such is present in the raw or filtered water. The statements of the authors and also the tabulated results apparently refer only to manganous salts and the presence of but 0.10 p.p.m. free chlorine. It would be interesting to have had results from manganic salts in comparison, and also results from solutions of manganous salts to which had been added dosages of chlorine higher than 0.10 p.p.m.

As to the peculiarities of the ortho-tolidine reactions with residual chlorine in the presence of mineral salts, the following experience may be of interest. This experience was with three different limestone waters having a pH less than 8 before the ortho-tolidine solution was added. The total bicarbonate alkalinity was between 150 and 185 p.p.m. in terms of $CaCO_3$. To 50 cc. of the chlorinated water containing 0.25 p.p.m. residual chlorine the addition of one drop of standard ortho-tolidine solution (10 per cent HCl) produced a blue color. A second drop changed the blue to a blue-green and additional ortho-tolidine added one drop at a time produced green, yellow-green, greenish yellow and finally the true yellow of the test. To produce the maximum color with such waters eight drops were required, this being the first experience where more than five drops (approximately 0.3 cc.) had been necessary for a 50 cc. sample, when not more than 0.5 p.p.m. residual chlorine was present. As a result, the instruction to plant operators, wherein only 5 to 10 drops of reagent (to a 50 cc. bottle of water sample) were called for, had to be changed to read "add 10 drops or slightly more, etc." The writer has always assumed that the hydrogen ion concentration of the sample was the cause of the additional reagent required above that previously found ample for the softer waters. It was not considered an important matter, however, as it was recognized that any amount of reagent less than

10 drops (0.5 cc.) to 50 cc. sample was not in accordance with the recommended procedure in the original method of Ellms and Hauser. It did point to the fact that, in the preparation of the ortho-tolidine solution, a quantity of hydrochloric acid in excess of that called for (10 per cent), was more desirable than a deficiency when the reagent was to be used in waters with high alkalinity. It is indeed fortunate that an excess of ortho-tolidine solution does not increase the intensity of the color above that produced by the quantity called for in the Standard Methods of the A. P. H. A.

In the presence of nitrites the starch-iodide test sometimes produces a false indication of the presence of free chlorine in the practical application of the test in sewage chlorination, whereas the ortho-tolidine test does not. Experience to date indicates that even for fairly turbid sewage plant effluents the ortho-tolidine test is more practical than the more cumbersome starch-iodide method when the quantities of residual chlorine are 2 p.p.m. or less. (Note: In applying the ortho-tolidine test to sewage plant effluents a method similar to determinations of pH value should be adopted, wherein small bottles or tubes are employed and viewed horizontally.) The authors' conclusions as to the merits of the ortho-tolidine over the starch-iodide test in the presence of nitrites therefore seem to be confirmed in actual practice.

Reviewing the results obtained from the study of organic compounds it is rather interesting to note that urea apparently did not absorb the chlorine added. On the other hand, uric acid, starch and gelatine did. It would have been extremely interesting to have had results from higher dosages than 0.05 p.p.m. chlorine. Experience indicates that the greater the chlorine concentration the greater is the quantity and the more rapid is the chlorine disappearance due to absorption or reaction with the organic matter present.

An important point, when considering the results obtained from the ortho-tolidine test in the presence of nitrogenous organic matter in solution, is the retarded color development after the reagent is added. Even at temperatures above 75°C. occasionally the chlorinated sample containing ortho-tolidine will have at the end of the first minute contact only a faint color indicating free residual chlorine. The presence of the acid seems to liberate slowly free chlorine from the organic-chlorine combination with consequent gradual increase of yellow color. This gradual increase may continue for 15 minutes before the maximum is recorded. The color at the end of this long

period does not appear to justify consideration in terms of free residual chlorine as usually conceived, but must be assumed to represent a fairly stable chloro-substitution product. It is possibly akin to a chloramine or is perhaps a true, but relatively stable, chloramine. Upon addition of more chlorine this compound is apparently destroyed and true residual free chlorine appears. This is indicated by the prompt development of the maximum yellow color within five minutes or less after the ortho-tolidine is applied. The length of contact required for maximum color development becomes less than two minutes at temperatures of swimming pool water. From experience, taken in conjunction with sterilization efficiency, it has been the idea of the writer that true residual free chlorine is indicated by the color developed within 2 minutes after the reagent is added. The temperature of the sample should not be less than 20°C. (68°F.). To obtain the desired residual in plant operation the chlorine should be increased until the test indicates the desired residual at the expiration of 3 minutes or less after adding the ortho-tolidine.

It may be worthy of note that a very objectionable medicated taste imparted to a supply resulted from the apparent maintenance of 0.1 to 0.2 p.p.m. residual chlorine. The operator observing a gradual deepening of color had been waiting fifteen minutes or longer after addition of the ortho-tolidine before recording the residual. The complaints from the consumers were numerous. The remedy for the trouble was an increase of chlorine dosage until a residual of 0.3 p.p.m. was recorded after a contact of one minute only. This was in late summer and therefore the temperature of the water was above 20°C. This increased chlorine apparently destroyed the chlorine substitution compound which had been causing the trouble. A slight but non-objectionable chlorinous odor could be noticed at the full-flowing service taps in the city. This was far more acceptable than the previous taste and odor and resulted in the complaints ceasing. This prompt improvement justified instructions to control the chlorination to obtain a color equivalent to between 0.2 and 0.3 p.p.m. residual approximately one minute after addition of the ortho-tolidine to the sample. The contact period required between the chlorine and the treated water before making the test remained, as previously, ten minutes or more.

In 1921 careful consideration was given the several known methods for residual chlorine determinations. This was for the purpose of selecting the test appearing most practical to place in the hands of

inexperienced small plant operators in Virginia. The ortho-tolidine method was that finally selected for the same reasons as pointed out by Dr. Buswell and Mr. Boruff, viz., not only because of its superiority over other methods, in that it is less affected by interfering substances, but, what is still more important, because of *the simplicity of the method and dependability of the single reagent required.*

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SOFTENING PUBLIC WATER SUPPLIES[1]

By John C. White[2]

Confining our discussion to the State of Wisconsin, the public water supplies of many cities and towns are obtained from deep wells. The exceptions to this are in those communities located on the Great Lakes or in districts like Chippewa Falls and Eau Claire where the natural waters are very soft and obtained mostly from shallow wells.

Well and spring waters generally carry from 200 to 350 parts per million of total hardness, which is equivalent to from 12 to 20 grains per gallon, mostly salts of calcium and magnesium. Some well waters have a total hardness of 600 to 800 parts per million. Such waters are cool and palatable and, at their source, most of them are practically free from organic matter. In the latter respects they are suitable for public supplies; but because of their high mineral content they cause much trouble and entail heavy expense when put to any use for which they must be heated or evaporated, or where the hardness must be neutralized before the water can be used. A Special Committee made a very careful study of conditions at Madison in 1917 with a view to softening the entire city supply and extracts from the report of that committee will be used in this paper as occasion offers.

To most people water is water and if it is clear and cool and without objectionable taste or odor it is good water. The housewife complains if it is hard and resorts to the usual expedients to overcome its bad features. She pays the bill in extra labor and expense without realizing that it is a proper charge against the water, and she probably does not know that by suitable treatment the water could be softened to a degree that would eliminate most of her troubles and still leave it satisfactory for drinking and kitchen use.

The softening process is also effective in removing organic matter

[1] Presented before the Wisconsin Section meeting, May 27, 1925.

[2] Board of Water Commissioners, Madison, Wisconsin.

from the water and thus gives added protection where wells or springs may become polluted or surface supplies are being used. Evidences of this are shown in a report of sanitary tests by the City Health Department of Madison which gave the following results. The raw water from Lake Monona carried 8700 bacteria per cubic centimeter. After treatment in a Northern Water Softener the count was reduced to 11 bacteria per cubic centimeter, all harmless in character. The water was treated with a proper amount of lime and soda ash to reduce its hardness from about 16 grains down to 4 or 5 grains per gallon, was given a sedimentation period of four to five hours and was not filtered. Where surface supplies are used it is possible to combine softening and filtration and produce a very satisfactory water for all public uses.

IMPROVEMENTS NECESSARY

In earlier times, when 70 per cent or more of the population lived on farms and the town pump supplied the urban demands, it was possible for each family to have a reasonably adequate supply of rain water throughout the year. The per capita roof area was much greater than at present and cisterns were in general use. Hard coal and wood were the common domestic fuels and the smoke nuisance had not appeared. This has all been changed. The farm population is relatively smaller and the urban population is relatively greater. Congestion in the cities and the use of soft coal have eliminated the cistern as a means of securing a supply of soft water. Two alternatives are possible; one is for each home or enterprise to provide means of softening water for its own use; the other is for each city or town to soften its entire supply. The latter method is preferable in every way. It will give a more uniform and satisfactory product at much less cost, and it will provide soft water to many people who could not otherwise afford to have it, without laying as great a burden on the average citizen as he would carry in softening his own supply independently. For these reasons it is desirable to make such changes and improvements in our public water supplies as are necessary to keep pace with the changing conditions and modes of living. A number of cities are now successfully softening their entire supply.

EFFECTS OF HARD WATER

Water that carries more than 6 grains per gallon of incrusting solids is objectionable and expensive for the following reasons:

a. Boilers and heaters. It forms scale in boilers and water heaters which leads to early failure by overheating of the metal and increases the amount of fuel required to do the work. It may also set up conditions which are favorable to corrosion and cause failure by pitting or grooving.

b. Washing or cleansing. The hardness must be neutralized before any cleansing can be done. This requires an extra amount of soap or washing powder to "break" the water. The soap or powder can do no work as a cleanser until the demands of the water have been satisfied and the results at best are not satisfactory as compared to soft water, for the soap curd, formed by the reaction of the soap or powder, is insoluble, clings to the garments, person or vessel and is difficult to rinse out or remove. It is the dirty scum that floats on the surface of the water and leaves the high water mark on the bath tub. Hard water causes discoloration and roughening of fabrics and leads to rapid wear.

c. Effect on health. It is thought by some that the very hard waters are detrimental to health. The medical societies and physicians in general do not support that opinion. The Sub-Committee of the special water softening Commitee of the city of Madison in reporting on this subject, stated:

1. Hard water has no ill effect on the human body except that some people are affected with diarrhoea when they first begin to drink it, and its use in lavatory and bath may cause a slight roughening of very tender skins.
2. There is no scientific basis for the somewhat common impression that hard water causes goitre or hardening of the arteries.
3. The experience of cities where the water is softened indicates no deleterious effect on the public health, and the Committee expresses the opinion that softening would be beneficial in some respects.

d. Effect on food values. Hard water has no deleterious effect on food values, but some articles are more palatable when cooked in soft water. Softening to 4 or 5 grains might change the taste slightly.

Typical failures

In support of the statements made above figure 1 shows two failures due primarily to hard water. The left hand subject is a section of a small cast iron water heater which failed by cracking due to incrustation. The water passage is almost entirely closed with scale. The right hand subject is a section of a 5-inch feed-

water line which failed by corrosion after about two years service. The large pit on the inside of the pipe can be plainly seen. The line was renewed and a water softener was put in 12 years ago and there has been no further trouble. These are only two instances out of the hundreds which could be cited.

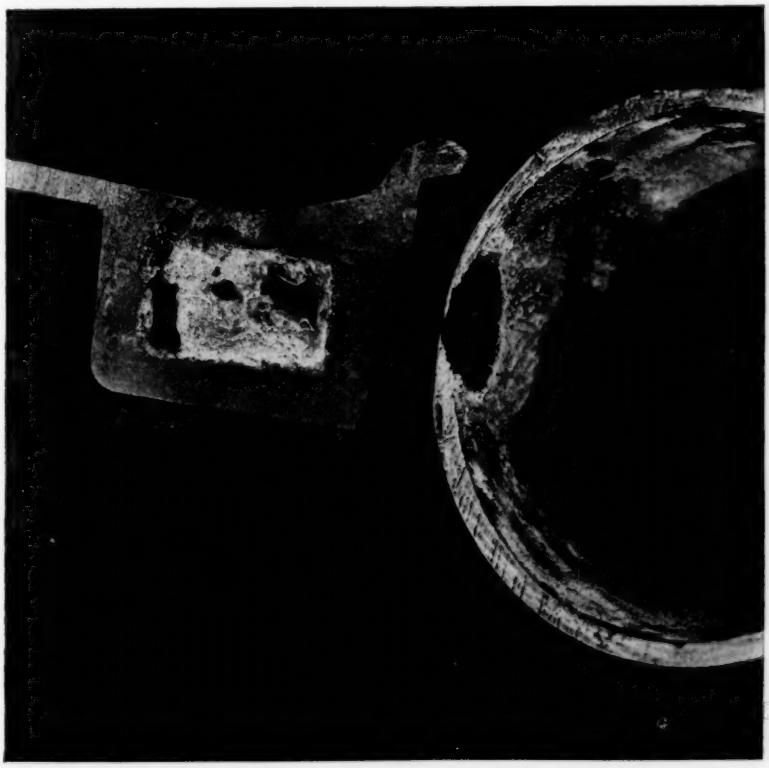

FIG. 1

SOAP CURD VISIBLE

Figure 2 shows by color the differences between hard and soft waters under the soap test. The same quantity of water, 50 cc., was put into each bottle. Starting at the left, bottle number 1 contains raw lake water; bottle number 2 contains softened lake water; bottle number 3 contains raw well water and bottle number 4 contains softened well water. The hardness in each was neutralized with standard soap solution. The differences in the quantities of

soap solution required are represented by the differences in level of the liquid content of the bottles. It will be noted that the softened waters took much less soap solution to form a lather than was required by the raw waters. The raw lake water is not as hard as the raw well water and the result is apparent in the greater clarity of its samples both raw and softened. Before being neutralized

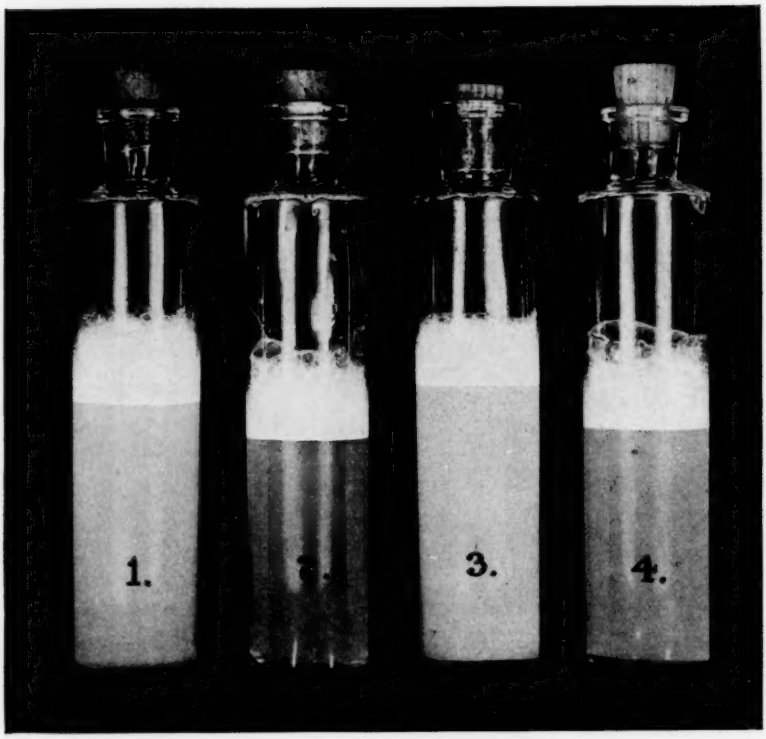

FIG. 2

by the soap solution all four samples were equally clear and sparkling. The milky appearance of the raw waters is visual proof that they are high in mineral matter, and the greater clarity of the softened waters is proof that most of the minerals have been removed.

EFFECT ON TASTE

It may safely be stated that very few people will detect any difference in the taste of raw and softened waters, if the softened water

is at the same temperature as the raw water to which they are accustomed. At a noon luncheon of a Madison Civic Club, some years since, the subject of water-softening was being discussed and, as a test on taste, softened well water was served with the luncheon instead of the regular city water. It was cooled down to normal temperature and the substitution was not noticed. The speaker called particular attention to the question of taste and the experiment seemed conclusive when more than 100 men whose minds were on the subject drank the softened water without observing any difference in the taste. At the close of his talk the speaker invited any who might be interested to come forward and taste samples of the raw and the softened water. A number did so and about half of them guessed wrong on which was the raw and which the softened water. The Club was then informed that softened water had been served with the luncheon and that the question of taste might be considered settled so far as those present were concerned.

METHODS IN USE

Two methods of softening are in general use. One is known as the Porter-Clark process and the other as the Zeolite Process. About 85 years ago an English Chemist, Dr. Clark, invented a process for removing carbonic acid and the carbonates of lime and magnesia by treating the water with lime. Later on Dr. Porter discovered that soda ash would remove the sulphates of lime and magnesia and the so-called Porter-Clark, or lime-soda process, is a combination of these two processes. The Porter-Clark process removes from the water the greater portion of the incrusting materials and leaves a minimum of sodium salts in solution.

The Zeolite process is a later discovery and uses either a natural Zeolite or a prepared Zeolite as a base and common salt as a reagent. The Zeolite process results in an exchange of the incrusting or hardening salts of the water for sodium salts which do not form scale nor react as hardness under the soap test. Because of the high sodium content of waters thus softened they are not desirable for boiler use, although they are said to be quite satisfactory for uses where continued evaporation does not take place. The sodium salts stay in solution in the water under any ordinary boiler conditions and form little scale. Under continued evaporation they cause a high concentration in the water in the boilers which, in conjunction with the suspended matter, always present in greater

or less degree, causes foaming and makes it necessary to blow-down frequently and introduce fresh water. The sodium salts are objectionable in other ways for boiler use.

The Porter-Clark process or some modification of it is in general use for softening public supplies and for steam uses. The Zeolite process is more generally used in hotels, hospitals, laundries, dyeing establishments and private homes. Waters softened by the Porter-Clark process are not generally reduced below 3 to 4 grains per gallon. The Zeolite process will give practically zero hardness, as indicated by the soap test, and, where the high sodium content is not an objectionable feature, it is satisfactory. Lime-soda softeners are now on the market for household purposes. A number of these are in successful use in Madison. Some advantages are claimed for them.

LIME-SODA PROCESS

The lime-soda process being much better suited to the softening of public supplies no further consideration will be given to the Zeolite process.

The mechanical equipment for the lime-soda process consists of a small tank for the mixing of the chemicals, some means of stirring or agitating the mixture, a proportioning device for feeding the proper quantity of the mixture to the raw water, a large settling tank into which the treated water flows, a filter and a blow-down or sludge pipe for discharging the precipitated matter that is removed from the water. Figure 3 shows a simple form of softener in which all of above parts appear. It is known as the water wheel type in which the power for operating the chemical mixer is obtained from an overshot waterwheel driven by the flow of raw water entering the softener. A paddle wheel does the stirring in the chemical tank; the chemicals are elevated by a bucket chain to a constant level cup from which the proper quantity finds its way to the wheel chamber where it mixes with the raw water leaving the wheel and enters the down-take. The surplus chemical overflows the cup and returns to the chemical tank. Proportioning is effected by maintaining constant heads on fixed orifices for both the raw water flow and the chemical feed. The strength of the chemical mixture is varied to suit the water being treated. The settling tank should have sufficient capacity to permit a five-hour period of sedimentation at the rated capacity of the softener. The treated water flows from

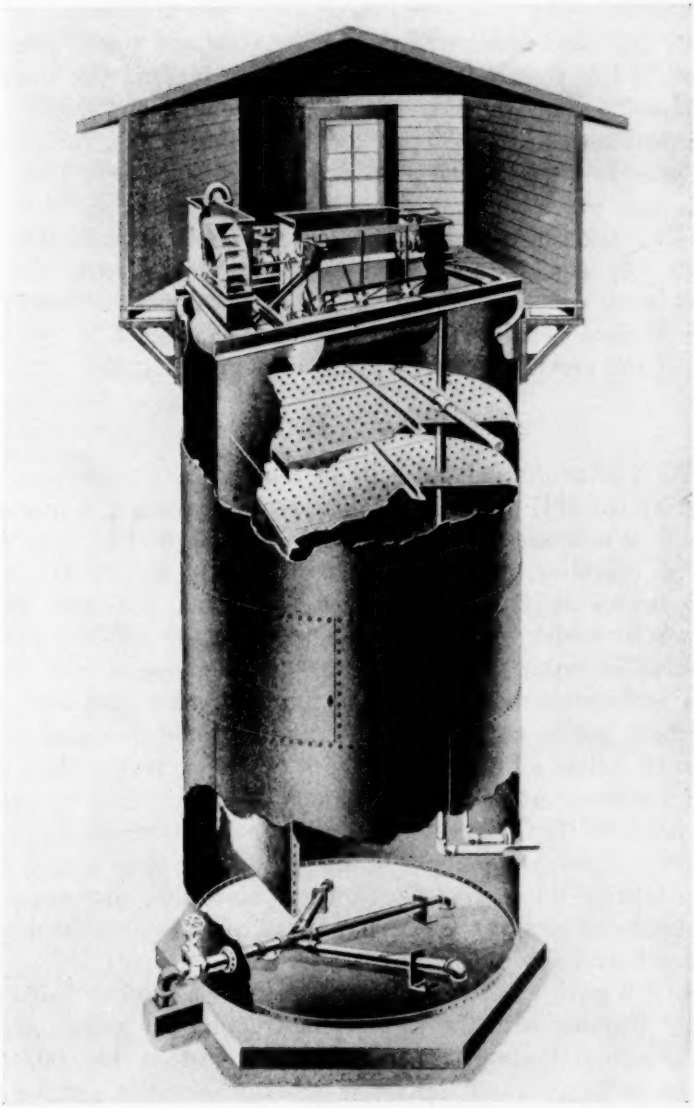

FIG. 3

the wheel chamber to a vertical passage called the down-take which conducts it to the bottom of the settling tank, in which it rises, passes through some sort of a filter or strainer and is drawn off for

use from the space above the filter. Operation is constant at full capacity and the machine automatically stops and starts when the demand is less than full capacity. By this method the machine maintains the same rate of treatment when running and fluctuations in demand are met by stopping and starting. The variation in head between stopping and starting levels is from 12 to 16 inches in the clear water chamber above the filter.

The operation of a lime-soda softener is neither complicated nor difficult. It should be directed by a qualified person, but the routine work can be done by the average water-works employee. Where surface supplies are used sanitary treatment is generally required and provision must be made for it in such cases.

RELATIVE COSTS

Table 1 gives the indirect costs of the hard city water as determined by the 1917 Committee. The cost of installing a municipal softener as estimated at that time was $125,000.00 and the annual cost of operation, including everything, was $38,225.00. From these figures it is apparent that the saving the first year of $174,429.00 would have more than paid for the softener and its operation as estimated at $163,225.00. The project was turned down and cannot now be revived for the reason that new wells have been put in at distant points and it would be impracticable either to deliver all of the water to a central softening plant or to have a softener at each well or group of wells. Had the recommendations of the Committee been carried out and the citizens learned the advantages of a supply of softened water they would never again tolerate the present hard water. Since that time many private softening plants have been put in and to that extent the demand for a softened city supply has been reduced.

Table 2 gives a list of cities that are now softening their entire supply together with the cost of construction per million gallons. The Madison Committee estimated this cost at $25,000.00 per million gallons. Table 3 gives the cost of operation for the same list of cities.

Economic results. The Committee report for Madison gave a cost of $38,225.00 annually for operation. This included all investment, overhead, operation and maintenance charges for a plant of 5 million gallons daily capacity. It represents a total cost annually of softening from 4 to 5 million gallons of water daily.

The sum stated is less than $1.00 per capita. The hard water is now costing about four times that sum. The cost of the hard water to the citizens of Madison, which they paid and are paying indirectly, was conservatively estimated at $174,429.00. If these figures be accepted as correct a municipal softening plant would effect a saving of over $135,000.00 annually and the city would have a more desirable water for all uses.

TABLE 1

Annual cost of hardwater—Madison, Wisconsin

Cisterns and double plumbing, year from 1916	$56,358.00
Annual charge, repairs, interest, etc	10,000.00
Extra soap required	67,890.00
Domestic water heaters	19,981.00
Heating boilers	19,000.00
Power boilers	1,200.00
	$174,429.00

TABLE 2

First cost of municipal plants in America—October, 1915

PLANT	DATE OF ERECTION	POPULATION	MILLION GALLONS DAILY		COST OF CONSTRUCTION	
			Rated	Actual	Total	Per million gallon rated capacity
St Louis, Mo	1915	687,029	160	100	$1,495,000	$9,344
Columbus, Ohio	1906	181,511	30	18.4	590,780	19,693
Grand Rapids, Mich	1910	112,171	20	14.0	449,559	22,478
McKeesport, Pa	1908	42,694	10	3.6	250,000	25,000
Owensboro, Ky	1906	16,011	3	1.5	30,000	10,000
Oberlin, Ohio	1903	4,365	0.75	0.28	12,000	13,300
Daytona, Fla		3,082	0.30	0.17	4,304	14,347
Hinsdale, Ill	1915	2,451	1.0	0.30	18,000	18,000
Port Tampa, Fla	1914	1,343	0.24		7,000	29,100

OBJECTIONS TO SOFTENING

The first thought that enters the public mind, when filtration or softening is proposed, is the fact that chemicals are put into the water and that the process must necessarily be quite involved and the results uncertain and dangerous. The average citizen does not

know that a perfectly clear water may be heavily charged with minerals in solution or that it may carry dangerous organisms in great numbers. He has the common notion, which has prevailed from the time of Jacob's well and the old oaken bucket down to bottled spring waters, that anything which comes out of the ground and can be labelled "Spring Water" or "Artesian Well Water" must be pure and wholesome. He does not know that some ground waters are so heavily charged with certain minerals that their use would be fatal, nor that others would not quench thirst. He will accept the statements of promoters that certain so-called

TABLE 3

Annual cost of operation and chemicals used—municipal softening plants October, 1915

PLANT	ACTUAL QUANTITY, MILLION GALLON PER YEAR	AVERAGE HARDNESS OF WATER RAW, PARTS PER MILLION	CHEMICALS USED—POUNDS PER MILLION GALLONS					OPERATORS REQUIRED	COST OF OPERATING PER MILLION GALLONS
			Lime	Soda ash	Iron	Alum	Hypo		
St Louis, Mo	54,656	170	800		415		1.6	35	$4.56
Columbus, Ohio	6,716	300	1,384	1,054		260	4		17.48
Grand Rapids, Mich	4,506	235	1,250			120		16	11,34
McKeesport, Pa	1,314	350	1,800	350	125	238			27.57
Owensboro, Ky	547	300	2,000	75			1	2	10.05
Oberlin, Ohio	102	300	2,045	735				1*	13.49
Daytona, Fla	62	360	2,910	250				1*	23.80
Hinsdale, Ill	100	360	4,091	1,368		†		1*	30.00

* Part time of one man.

† Small amount.

mineral spring waters have medicinal properties and gladly buy and use them when he could probably draw a better and safer water out of his kitchen faucet. He refuses to accept the plain statements of fact as to scientific water treatment and purification and he resists every attempt to improve his water supply and reduce its cost by any such methods. In spite of all this he will visit other cities, particularly the larger ones, where surface supplies are given scientific treatment, use the treated water without knowing it, and return none the worse for his experience. His objection rests, not on any knowledge of the subject, but on the sentiment

which he feels for the words spring or well and on his aversion to the words chemicals and treatment. If he could realize that all fresh waters have the same history and that they must be purified either by natural or artificial methods before they are safe and satisfactory for domestic use, he would probably forget his sentiments and accept real reformation instead of the fancied virginity he thinks he is getting.

The hard water bill must be paid. It is a tax that cannot be evaded. It can be greatly reduced by softening the supply.

DISCUSSION

O. A. HOUGEN:[3] In addition to the evil effects of hard water when used for boiler or laundry purposes, as stated by Mr. White, it might be well to call to mind other serious disadvantages in the use of hard water in connection with other industrial operations.

In paper making, iron-containing waters deposit ferric hydroxide. This gives the pulp a brown color which is carried along to the finished paper. Temporary hardness in water, due to the presence of the bicarbonates of calcium and magnesium, decompose the resin soap used in sizing, thereby preventing the size from adhering to the wood fibers. Alkaline waters consume large quantities of the alum used in sizing. Suspended matter in water is retained by paper, prevents proper bleaching and causes dark specks on the finished paper. Acid waters interfere with the sizing, decompose the colors and cause streaks.

In textile industries, hard water produces serious consequences. Calcium and magnesium compounds precipitate various dyes in the dye vats, causing irregular dyeing, colors off shade and dyes which easily rub off. In addition, the presence of these constituents causes high loss of valuable dyes. Iron containing waters are bad, particularly in mordant dyeing. In bleaching processes iron causes a muddy brown appearance.

In the scouring of textile fibers the same difficulty is encountered with the use of hard waters as is met with in laundries—an increased soap consumption and clinging of mineral matter to the fibers. In the scouring of wool the desirable potash in the steep water is diluted with mineral impurities from hard waters. Silk in particular is

[3] Assistant Professor of Chemical Engineering, University of Wisconsin, Madison, Wis.

injured by hard water causing discoloration of the dyes, cracking of the fibers and irregularity in weighting.

In leather manufacture, the presence of bicarbonates in the water used in unhairing precipitates carbonates in the dermic tissue of the hide, thereby preventing the proper action of tanning agents. These same constituents destroy part of the tannin in the tan vats. Organic matter in water causes the early decay of leather products. The presence of iron causes uneven discolorations on the finished leather.

When used for irrigation purposes water containing a high content of alkali may prove entirely valueless.

Mr. White has called attention to the two standard types of water softeners—the lime-soda ash method and the zeolite (or mineral exchange) method. In addition water may be softened for boiler purposes by the use of so-called boiler compounds. This method is however quite unreliable, greatly increases the suspended matter in the boiler and causes deposits on boiler tubes which may retard heat flow to the same extent as boiler scale. Distillation is also a means of water softening, but because of its high expense can only be resorted to where no other remedy can be applied as in the removal of poisonous constituents.

The lime-soda ash method is particularly suitable for waters of extreme hardness and for waters containing much iron and manganese. The chemicals used are cheap and there is no fluctuation in the capacity of the apparatus with waters of different degrees of hardness. The softened water is low in total dissolved matter, hence causes little foaming. Corrosion is also minimized due to neutralization of acids. Water, softened by this process, is fit for drinking purposes provided an excess of chemicals has not been added.

The disadvantages of the lime-soda ash method are that the usual equipment takes up much space, tanks must be provided for sedimentation and filtration of sludge, an accurate chemical analysis of the water is required before prescribing the proper treatment, and exact proportioning of chemicals necessitates skilled attention. By the lime-soda ash method water can be softened to a minimum calcium content of 12 parts per million and a minimum magnesium content of 5.5 parts per million.

The zeolite (or mineral exchange) system is capable of producing a zero content of both calcium and magnesium. No attention is

required to the proportioning of chemicals and no additional filtration or sedimentation is necessary. The process is continuous and little space is taken up by apparatus.

The disadvantages of the mineral exchange system are that the capacity of the equipment is limited by the hardness of the water, much wash water is required in the regeneration of the mineral, and the method is not suited for waters high in iron, manganese or acid. The total dissolved solids in the softened water are as high as in the original water, hence there is little reduction in tendency to foam when used for boiler purposes. When the water exceeds 40 grains per gallon the mineral exchange system is not considered economical.

The lime-soda ash process is particularly well suited for treatment of boiler waters and city water supplies where skillful attention can be economically given to the proportioning of chemicals and to the operations of sedimentation and filtration. The mineral exchange system is well suited for the treatment of waters for laundry purposes, in textile mills, for dyeing, bleaching and for use in hotels and homes.

COMPOSITION OF MUD BALLS

By W. S. Mahlie[1]

During a period of construction at our filter plant recently it became necessary to apply water to the filters which had not been prepared properly on account of the sedimentation-coagulation basin and mixing basins being out of service. Wash water facilities were also hampered and the consequence was that we had an epidemic of mud balls.

We became curious to know whether there was any difference in composition between the large sized and the smaller sized ones. Eight samples (Numbers 1- to 8-inc.) were selected. In addition six extremely small ones were treated as one sample (No. 9) and the center portion of one of the larger ones (No. 10). The samples were all taken from one filter which appeared to be the worst offender. This filter had been in service since September 16, 1918, and had received iron-coagulated water from that time until July 4, 1923, at which time alum-coagulated water was used and continued until December 26, 1923, at which time the mud balls were taken.

On cutting through these mud balls there appeared to be a gradual darkening in structure until the center was reached, indicating probably that the mud balls had been rolled around and gradually built up, with a probable anaerobic bacterial action going on also. There appeared to be no exceptionally offensive odors from the mud balls as a whole, but the center portion when first exposed to air gave off a disagreeable odor. On drying, the color of both the inside and outside became alike, and the odors disappeared. Table 1 gives the various results of the tests and figure 1 shows the values plotted as curves.

The moisture was determined by drying in open pans at room temperature. The washing loss was determined by placing 1000 grams of the sample in a casserole, stirring thoroughly with water,

[1] Chemist in charge, Filtration Plant, Fort Worth, Texas.

and allowing the sand to settle and pouring off the supernatant liquid, repeating the process until the washings came away clear.

TABLE 1

SAMPLE NUMBER	WEIGHT, WET	WEIGHT, DRY	MOISTURE	WASHING LOSS*	EFFECTIVE SIZE	UNIFORMITY COEFFICIENT
	grams	*grams*	*per cent*	*per cent*		
1	8,980	5,720	36.30	18.4	0.45	1.44
2	7,480	4,775	36.16	17.3	0.46	1.43
3	3,880	2,845	26.68	16.8	0.46	1.41
4	12,510	7,850	37 25	19 6	0 53	1 40
5	1,120	705	37 05	20 1	0 51	1 43
6	2,380	1,505	36 76	22 8	0 51	1 49
7	2,800	1,815	35 18	20 7	0 53	1 45
8	27,720	17,285	37.64	19 7	0 54	1 43
9	2,750	1,585	42 36	21 1	0 51	1.49
10	2,590	1,585	38.80	18.6	0.52	1.48

* Dried sample.

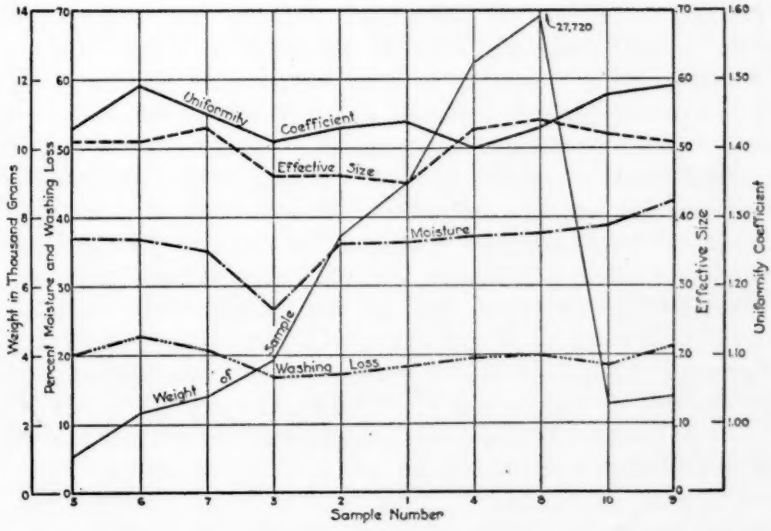

FIG. 1

The washings from these samples carried a peculiar reddish-brown floc which settled out very rapidly and looked a great deal like leaf loam. A sample of these air dried washings showed upon analysis:

	per cent
Ignition loss	31.61
Silica (SiO_2)	30 00
Iron and alumina (R_2O_3)	29.16
Lime (CaO)	7.92
Magnesia (MgO)	2.35
Manganese (Mn)	Trace
Total	101 04

It was noticed that, upon solution in acid before the sample was ignited, a blackish looking substance separated out, which appeared very much like carbonaceous material. Subsequent tests showed this to be true, and substantiate the previous statement relative to bacterial action going on within the center of the mud ball. This anaerobic action no doubt released the carbon from organic substances present in the water and was the cause of odors. From inspection of figure 1 there appears to be no relation between the size and composition of these mud balls.

CHLOROPHENOL TASTES IN MILWAUKEE'S WATER SUPPLY[1]

By Russell W. Cunliffe[2]

A clear conception of the rather complex problems encountered in the investigation set forth below necessitates an understanding of the geographical and industrial situation of Milwaukee. Milwaukee is located upon the shore of Lake Michigan and is pierced by three rivers; the Milwaukee River from the north, the Menomonee from the west, and Kinnickinnic from the southwest. The Menomonee flows into the Milwaukee River in the southern part of the down-town area, and the Milwaukee and Kinnickinnic Rivers converge into one mouth and flow into the harbor which is partially separated from the Lake proper by a break-water.

All industrial and domestic sewage, originating in the City and some outside communities, outfalls into the rivers and thence is carried into Lake Michigan from which the public water supply is secured. Prior to December 23, 1918, the water intake crib was three and one-half miles northeast of the mouth of the rivers. The crib of the new intake tunnel, in operation since the above date, is in 67 feet of water and five miles northeast of the river mouth. Chlorination is the only safe-guard of the City against water-borne diseases, although it is anticipated that within the next year the new sewage disposal plant will treat all sanitary sewage originating in the drainage area, including Milwaukee and numerous outlying smaller communities. This City is one of the large manufacturing centers of the country and many types of industries may be found on all of its rivers and for many miles along the shore of Lake Michigan to the south of the City. There is a gas plant of one type or another located upon each of the three above mentioned rivers and within the City.

Hypochlorite of lime was first applied in the disinfection of Milwaukee's water supply in June, 1910. On March 31, 1915, for obvious reasons, liquid chlorine was substituted. Complaints of chlo-

[1] Presented before the Water Purification Division, Louisville Convention, April 29, 1925.

[2] City Chemist, Health Department, Milwaukee, Wis.

rine tastes in the water were received from time to time from the first use of chlorine or its compounds, and it is probably true that, when hypochlorite of lime was used, largely due to difficulties encountered at that time in controlling its application, chlorine tastes were experienced.

However, even following the installation of liquid chlorine apparatus, justification for occasional complaints of apparent chlorine taste were obvious. These tastes were referred to as of a "medicinal" character and appeared to be the same as, or very similar to, the taste of a dilute solution of chlorine. However, the situation became progressively worse, especially in 1917 and 1918, with more frequent and increasingly intense tastes. Where previously practically all of the taste incidents had occurred during the winter months and were presumably attributable to the retarded absorption and dissipation of the chlorine on account of low temperatures, in 1918 the tastes in summer were as frequent, prolonged and marked as during the low temperature periods of the year. It was noted that, whereas taste due to chlorine gas in solution could be eliminated by boiling, this medicinal taste not only was unaffected by such procedure, but imparted its characteristic and highly objectionable flavor to tea, coffee and any other food to which water containing it was added. In 1918 these periods of taste sometimes lasted four or five days. Citizens could neither drink sufficient water nor eat food prepared with it. The situation had become an exceedingly serious one and, needless to say, the public was exceedingly and justifiably resentful.

Every known procedure was resorted to in an effort to eliminate this taste. Experimental filtration of various types, aeration, carbonation, and treatment with hyposulphite and other chemicals failed to have any effect whatsoever in diminishing the degree of intensity of taste. A close check was maintained upon the amount of chlorine applied to the water supply and determinations of the residual or free chlorine by the ortholidin method during periods of taste showed a less amount during such periods than normally, as the chlorine was reduced to minimum requirements at such times. As the water supply possessed no unusual flavor prior to the application of the chlorine, and, as mentioned above, the intake was located three and one-half miles from the mouth of the rivers, the problem appeared to be related to some unknown chemical behavior of chlorine itself or an impurity mixed therewith.

In 1918, some general observations having been made on wind

directions and durations, suspicions were aroused that possibly trade wastes emptied into the rivers in the City might after all have some

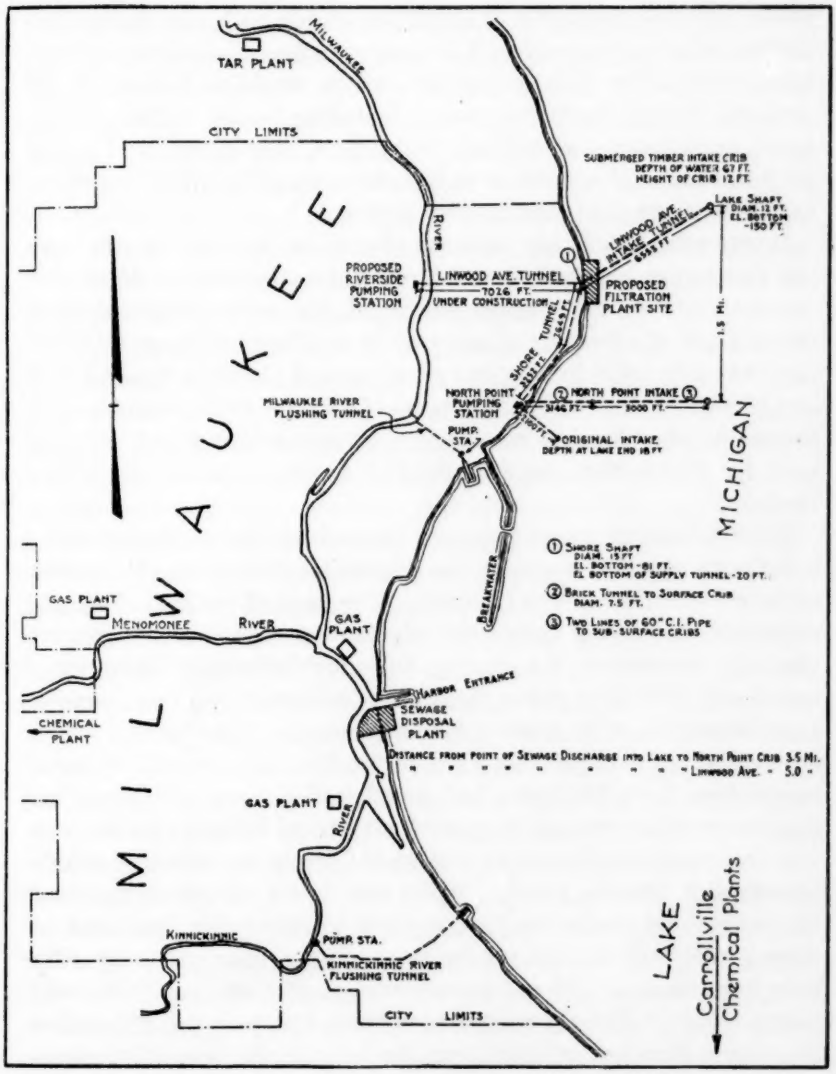

FIG. 1

connection with the taste occurrences, inasmuch as conditions preceding taste incidence appeared very similar. Samples of liquid

waste effluents from the different industries in the City were collected, chlorinated, and boiled to remove traces of free chlorine, cooled and tasted. Only wastes from gas plants and industries whose effluents contained products associable with the destructive distillation of coal were found to possess taste. Laboratory experimental work was then undertaken which established that of the products derived from this source, including benzol, xylol, phenol, cresol, naphthalene, anthracene, and others, only phenol and cresol produced tastes of a stability and flavor comparable with those which had been experienced, and in great dilution.

It was established that, whereas phenol, in dilutions greater than one part to two hundred thousand parts of water, was not detectable through taste by the average individual, the same compound after the addition of a fraction of one part in a million of elemental chlorine, was detectable in dilutions of one part of phenol in two hundred and fifty to five hundred million parts of water. Thus chlorophenols, formed by the chemical combination of waste phenol and chlorine used for disinfection, were established as the cause of the City's troubles.

While this development indicated the path of future investigations, it did not irrefutably single out the responsible industries or the extent of the contribution of each industry. The scope of the field of sample collecting directly at industrial plants was accordingly extended virtually throughout the county to industries whose waste effluents found their way either directly or indirectly into the rivers or Lake Michigan. The cities of South Milwaukee and Cudahy, which are located ten or more miles south of the City and secure their water supply from Lake Michigan, had complained bitterly with regard to the taste experiences and, in general, attributed them to two or three chemical plants in the nearby village of Carrollville, although unable to establish definite proof. While this latter situation appeared interesting and similar to the situation in Milwaukee, inasmuch as these plants were located on the shores of the Lake, some 13 miles from our intake, it did not appear evident at that time that these plants could be directly connected with or influence the Milwaukee situation. Samples collected from the Lake, in the immediate vicinity of these plants, upon chlorination developed the characteristic tastes which were now known to be due to chlorophenols, although the area of the lake found to be impregnated with taste-producing compounds on any of the earlier trips did not appear to be sufficiently great to affect Milwaukee.

Regardless of location, however, it was exceedingly desirable to determine to what degree each plant was a possible contributor to the exceedingly obnoxious situation which existed. To establish this an estimation was made of the number of gallons of effluent from each plant in twenty-four hours. Numerous samples from each of the plants were secured and the greatest dilution determined which would produce taste upon chlorinating, boiling and restoring to original volume of dilution taken. This dilution figure times the total of gallons of effluent from a given plant in twenty-four hours roughly established the number of gallons of water which could be polluted to a degree to cause obvious taste upon the addition of chlorine. This factor was expressed in millions of gallons and designated the taste-producing power of each plant involved.

The Newport Hydrocarbon Company, located at Carrollville, and engaged in the manufacture of phenol, discharged an effluent with a taste-producing power enormously greater than any other plant, with a local coke and gas plant within the City occupying a very important second place. The managements of both of these companies disclaimed vehemently that they were in any way responsible for the situation; one of them running full page display advertisements to that effect in the daily newspapers. In all, eight plants appeared to be involved in a major degree.

An extensive study had been and was being made of the meteorological conditions which preceded, accompanied and followed the taste occurrences, and was confined to official wind, precipitation, and other data secured from the Milwaukee office of the United States Weather Bureau. Wind data for each period of taste appeared very similar and on charting this information the graphic pictures presented were virtually identical. This established the fact that taste incidence always followed periods in which the wind was from the direction of the mouth of the rivers and Carrollville toward our intake; that is, southerly winds in general and southwest in particular.

The next step was the inauguration of an extensive day and night campaign of sample collecting. For this purpose crews were placed upon the rivers, provided with motor boat or row boat and the necessary sampling equipment. A chemist was in charge of each crew at practically all hours, with a definite predetermined schedule to govern time and place of collection. This precaution was observed in the event of the necessity of court proceedings. Regular collection and supply stations were established and arrangements made to trans-

port the collected samples to the laboratory for testing as promptly as possible, and never more than twelve hours after collection because of the absorption of phenol by certain constituents of sanitary sewage; an apparently irreversible reaction.

Incidentally it should be mentioned at this time that the process of adding a trace of chlorine solution to water samples to be tested for phenol, boiling for five to ten minutes, to expel residual chlorine and as an additional means of protecting the laboratory workers against infection from grossly polluted samples, cooling, restoring to original volume with taste-free water, testing for free chlorine by the orthotolidin method and tasting, had been established as the standard method of detecting the presence or absence of phenol. For its purpose and the connection in which it is used, this method appears to be as dependable in experienced hands and far more sensitive than colorimetric or other methods subsequently developed.

All samples were tasted by two or more observers and the degree of intensity of taste noted; that is, very slight taste, slight taste, taste, strohg taste, or very strong taste. Samples possessing a strong or very strong taste were diluted with taste-free water to a definite dilution, and the maximum dilution which would still produce taste determined. The chemists engaged in this work became remarkably proficient in agreeing upon the intensity of taste present.

As previously mentioned, samples had also been collected in the lake to determine to what degree the Carrollville plants, which, as has been stated, were 13 miles from our intake, were possible contributing factors. For this purpose a 20-foot gasoline motor boat had been used, which possessed an engine having the happy faculty of stopping whenever the boat was precariously near the rocks lining the shore. It was obvious that operations could not successfully be carried on in this way, particularly during those storm periods of high wind velocity when the necessity for sampling work was greatest. Incidentally, suspicions with regard to these plants had not been allayed by results of previous investigations. To meet this situation arrangements were made to have a powerful tug steamed up and available at all times, and a large reserve supply of sampling equipment.

Awaiting the initial appearance of an additional taste recurrence of unusual intensity under the influence of strong southerly winds, the equipment was hastily loaded upon the tug and a sampling trip made through the bay at Milwaukee to a point above or north of the

intake and along the shore to a point south of the chemical plants at Carrollville, a distance of approximately 14 miles. Samples were collected at frequent intervals at the surface and 10 and 20 feet below the surface. Testing of these samples established that this tremendous body of lake water was impregnated with phenol to an extent to readily develop chlorophenol taste of varying degrees of intensity; that the principal source of our trouble originated at Carrollville, and that the contributing plants in Milwaukee were relatively minor factors. It was subsequently developed that the Newport Hydrocarbon Company was operated by a private corporation for the United States Government, and that it had been progressively increasing its phenol production from three or four tons per day in March, 1916, to one hundred and thirty tons per day in November, 1918. Following this campaign of investigation, which lasted for a number of months, the evidence secured was presented to the United States War Department through the United States Public Health Service. The war being then over and the vital military necessity for phenol production having ceased, steps were taken by the federal government for the immediate closing of the plant.

It was hoped that, following the elimination of this primary offender and the placing in service of the new intake five miles from the mouth of the rivers, the waste effluents of the Milwaukee plants would prove of inadequate concentration to survive the dilution incidental to their passage through the rivers and Lake to the intake and still acquire detectable taste upon addition of chlorine. This hope proved to be justified only in part. For a year no chlorophenol tastes developed. However, on December 4 and 5, 1919, and March 8, 9 and 10, 1920, there were recurrences of greatly reduced intensity as compared with previous experiences.

According to the United States Engineering Department there are no established currents in this part of Lake Michigan, movements in this body of water being influenced by wind action. From this same Department estimates were obtained as to the length of time required by winds of given velocities to reverse the direction of flow and establish a water movement of equal speed in the opposite direction. Checking this information and past experiences against the wind charts demonstrated that the trade wastes causing later recurrences of taste could not have had their source in Carrollville, but must have been derived from polluted river water. These deductions were confirmed by immediate investigation at the Carrollville plants.

A more extensive and systematic sampling campaign was again undertaken on the rivers, with the mouth of the rivers as the initial point. This work was gradually extended up the three rivers to points beyond the industrial areas or until even incidental samples no longer acquired the much sought for taste upon chlorination. Day and night crews were maintained, as high as twenty men being employed in this work at times during twenty-four hours. Over four thousand samples in all were collected and tested. The results of the taste-tests of these samples were graphically charted, showing the percentage of total samples collected at each station developing taste and the degree of intensity of taste. These charts showed that the Semet-Solvay and coal gas plants were responsible, whereas the water-gas plant using only coke from which the phenol had been removed in the process of manufacture did not produce any objectionable effluents. Analyses of ammonia concentrate waste liquor from the former plants, as made by the Skirrow modification of the Messinger and Vortmann method (Jour. Soc. Chem. Ind., vol. 27, p. 58, January 31, 1908), showed that 0.67 pound of phenol is wasted for each ton of coal coked.

Experimental work has shown that phenol-containing wastes may be satisfactorily disposed of by mixing with sanitary sewage, assuming a sufficient volume of the latter is available, in which the phenol appears to be absorbed primarily by the nitrogenous matter. At present all phenol-containing wastes have been disposed of with one important exception. This one, consisting of 300,000 to 400,000 gallons of ammonia concentrate waste liquor daily, will be taken care of as soon as the necessary sewer connections and the sewage disposal plant have been completed.

It should be stated at this time with regard to the industries involved that once the necessary evidence was produced definitely connecting their wastes from operations with recurrences of tastes, their managements met the issue fairly and squarely and in a spirit of coöperation.

This article would not be complete without a grateful acknowledgment of the suggestions and assistance given by H. P. Bohmann, Superintendent of Water Works; C. M. Baker, Wisconsin State Sanitary Engineer, and R. L. Piper, Chemist, Water Works, in successfully carrying out these investigations.

DISCUSSION

C. M. BAKER[3] The State Board of Health was called in on this question originally in 1918. Investigation at that time, as pointed out by Mr. Cunliffe, indicated that the principal source of trouble was the Government Phenol Plant at Carrollville, 15 miles distant. The Board of Health was again called in March, 1920, when there was a recurrence of objectionable odors as referred to in the paper. There were those at that time who even advocated closing the gas plants or preventing them from discharging wastes into the rivers. If this had been done, however, many a cold meal would have been eaten in Milwaukee.

In all previous tests made of samples collected in the harbor or river, particularly in the main harbor, there was no record of samples which gave a taste after treatment with chlorine. It was evident, therefore, that there were some other controlling factors not yet demonstrated. For that reason a more extensive collection of samples and analysis was outlined and undertaken.

Sampling was commenced in the harbor and continued up the river at different places. At first no positive results were secured, notwithstanding the fact that the concentration of wastes must be much greater in the harbor than it could be at the intake 5 miles distant. Finally one day, when the wind was blowing from the west, tastes were observed in samples collected in the harbor. Further study traced this condition further up the river to the junction of Milwaukee and Menomonee Rivers, thence further up the Menomonee River only, to just below the gas plant. Under normal conditions tastes could not be detected in samples from the lower Kinnickinnic, but occasionally they were observed.

The effluent from the Coke and Gas Company plant discharges into a slip tributary to the Kinnickinnic and not directly into the river itself. There is thus an accumulation of these wastes in the summer time. The Milwaukee and Kinnickinnic Rivers are flushed by water pumped from the lake through tunnels, but the Menomonee is not flushed and, because of the exceedingly low flow at times accumulation of wastes may also occur below the plant of the Milwaukee Gas Light Company. Correlation of the analyses with the wind data indicated the occurrence of tastes more pronounced where a west wind was followed by a wind from the Southwest. The con-

[3] Sanitary Engineer, State Board of Health, Madison, Wis.

clusion was quite apparent. Large accumulations of wastes from the Gas Light Plant in the Menomonee River and from the Gas and Coke Company in the slip tributary to the Kinnickinnic River, were flushed out of the harbor due to lowering of the lake level by the wind. A southwest wind following carried the pollution to the intake.

The original idea in solution of the problem was to provide gradual and continuous discharge and thus prevent accumulation. A dam or baffle provided with a small opening was constructed across the slip tributary to the Kinnickinnic so that the discharge would be gradual at all times, and the wastes from the Gas Light Plant was pumped into a sewer that discharged directly into the Milwaukee River. These improvements apparently eliminated the difficulty until about a year ago last winter when there was a recurrence, but apparently because operation of the flushing tunnels had been discontinued, thus again allowing accumulation in the rivers and harbors. The gas plants then arranged to pay for the operation of flushing tunnels during the winter. Since this time no further difficulty has been reported.

It is true, as stated in the paper, that the combination between the waste and sewage tends to eliminate the taste producing quality of the waste. That was one factor in the solution of the problem, but perhaps the main factor was the question of continuous dilution and the prevention of accumulation.

It might be added that the city of Oshkosh a couple of years ago had trouble with taste in their water supply. After investigation it was recommended that the gas plant waste be used for quenching the coke, but the company after studying the situation and securing experts suggested that the wastes be discharged into a public sewer. Data were presented to indicate that this method of disposal would be satisfactory. Their contention was based largely upon actual tests made by hauling wastes from the plant in tanks and discharging it into the sewer at a rate approximately the same as would be anticipated from the plant. Tests indicated that tastes produced by the waste were thus eliminated. The suggested procedure was therefore permitted. Since that time there have been no further complaints from Oshkosh.

While definite data are not available as to the ratio of sewage or organic matter to the industrial waste that should be provided to prevent taste, it is very evident that such a mixture is a material

factor in eliminating the taste producing powers of phenol wastes. Tests at the experimental plant of the Milwaukee Sewerage Commission indicate quite conclusively that the activated sludge process will take care of the situation when the wastes are discharged into the public sewerage system and the treatment plant placed in operation. The ammonia concentration liquor from the gas plant was added to the sewage in an amount equivalent to 2.7 per cent of the volume of sewage and for a short period as high as 6.6 per cent was added with no apparent interference in the operation of the sewage treatment plant and practically complete removal of the taste producing properties of the wastes.

F. E. HALE:[4] I would like to ask what is the time limit?

C. M. BAKER:[3] The time for travel of the waste to the intake was rather short, only a matter of four or five hours. Of course, this would depend somewhat on the intensity and duration of the wind. The most severe conditions were preceded by a west wind followed by one from the southwest.

N. J. HOWARD:[5] May I ask the period of year that the experiments were carried out with the activated sludge process, of the city of Milwaukee. My recollection was that that was tried out in the summer time.

C. M. BAKER:[3] The tests were made during the summer only, but laboratory tests made by submerging tubes in ice water indicated satisfactory results. This latter, however, would not be analogous to normal winter operating conditions.

N. J. HOWARD:[5] There was a general assumption that increased biological activity, which occurred in the effluent, did actually either destroy or prevent the taste formation. I would like to know whether the same conditions would prevail in the winter months when biological activity was very much less.

[4] Director of Laboratories, Mt. Prospect Laboratory, Brooklyn, N. Y.
[5] Bacteriologist in Charge, Filtration Plant Laboratory, Toronto, Canada.

MORE TYPHOID FEVER FROM CROSS-CONNECTED AND DUAL WATER SUPPLIES[1]

WINONA LAKE, INDIANA

An outbreak of typhoid fever occurred at Winona Lake, Ind., during the latter part of June and the early part of July which is now believed to have been caused by cross connections which permitted polluted water to enter the mains carrying the public water supply.

The number of cases resulting is now known, as many cases occurred among persons from other States who attended a conference held at Winona Lake from June 4–12. Reports received by Doctor King, State Commissioner of Health of Indiana, show that cases have occurred among persons in attendance at the conference from eight States other than Indiana. On July 2 there were reported at least 11 cases of typhoid fever in Winona Lake and community, and several additional doubtful cases.

From the data available, it seems very probable that the infection was carried into the public water supply of Winona Lake through two cross connections between the public water supply system and a system used for pumping surface water from a canal for use in sprinkling lawns and flushing toilets at the comfort stations on the parkway where the conference was held. Information obtained from residents in a house-to-house canvass in the area surrounding these cross connections, revealed that, in practically each instance, the water used from the city mains during the time when the conference was in session, was bad in taste. It was also learned that there were many cases of severe gastro-intestinal attacks, as well as cases of typhoid fever, either in the homes or among persons visiting them. Canvasses made in other sections of the city showed on the contrary, that few persons noticed any change in the taste of the water and that there were few cases of gastro-intestinal trouble and no cases of typhoid except among persons who had drunk water from faucets in the area near the cross connection.

[1] Reprinted by permission from Public Health Reports, Vol. 40, No. 34, p. 1761, August 21, 1925.

The taps nearest the cross connections were a row of drinking-water faucets which had been installed for the use of the public while the conference was in session. This probably accounts for the greater prevalence of typhoid fever among the visitors than among the residents, as seems to have been the case. A barber shop in the vicinity of the cross connections was visited by the investigator, and the barber stated that the water obtained from the city mains during the time of the conference was unfit for use, and that it had an odor similar to that of the canal water.

Investigation revealed that there were two cross connections between the canal water system and the public supply system. There was no evidence that the valves had been tampered with. There was evidence, however, that a closed valve in the canal system was leaking. Tests made on July 1, before the cross connections were broken, of the water obtained from a tap in one of the houses in the suspected area, showed that it was highly contaminated. Tests made July 12 and July 21, after the connections had been broken and the water chlorinated, showed the water to be satisfactory bacteriologically.

Additional evidence that the canal water had been entering the city mains is presented by the fact that a large meter recording the flow of water in the area involved was shown to have been turning backwards.

In order to remove the danger from the above-mentioned cross connections, and any others possibly existing, the pump on the canal bank was dismantled and removed. The canal water is stated to be unfit even for sprinkling purposes, since contamination might be spread by such use.

It appears that these cross connections had been installed in spite of an order made by the State Board of Health of Indiana more than two years ago that all physical connections between public water supplies and other supplies obtained from surface sources should be discontinued and making it unlawful for any such physical connections as those at Winona Lake.

Many states now have laws and regulations regarding cross connections. Some require double check valves where there is a connection between industrial supplies and the public supply main. In view of the fact that many outbreaks of typhoid fever and gastro-intestinal disturbances have resulted from such connections between the potable supplies and polluted sources, and since check

valves can not always be depended upon, it is of interest to present here the resolution passed at the American Water Works Association Convention in Louisville in April, 1925, concerning this subject:

> Whereas cross connections between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever and other water-borne diseases; and
>
> Whereas check valves and other similar protective devices can not always be depended upon; Be it
>
> Resolved, That no physical connection should be permitted between a potable public water supply and any other supply except as follows:
>
> 1. With another potable public supply.
> 2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.
>
> This prohibition to apply to all piping systems either inside or outside of any building or buildings; and be it further
>
> Resolved, That definite programs should be inaugurated in each municipality to permanently eliminate all other connections.

NIAGARA FALLS, NEW YORK[1]

A case of typhoid fever occurring in an employee of an industrial plant in Niagara Falls has been traced to polluted water in one of the supplies of a dual water system, according to the Health News of August 3, 1925, issued by the New York State Department of Health.

Investigation of the case by Dr. Edward E. Gillick, city health officer of Niagara Falls, eliminated all probable sources outside the factory where the patient was employed. When representatives of the health department visited the factory they discovered that, in addition to the municipal water supply connected with the drinking fountains, the company had a private water supply which was obtained directly from the Niagara River. This water was filtered, but not chlorinated, before being used for commercial purposes. Water faucets for the wash basins in the rest rooms were found to be connected with this private supply. As no warning notices had been posted, it was stated to have been common practice for the employees to use this water for drinking purposes. Analysis of the water showed it to be badly polluted. Warning notices stating that the water was unfit for drinking purposes were posted by the company as soon as it learned that this was the cause of the typhoid case.

As other cases of typhoid fever had previously been traced to factories using raw river water for commercial purposes, the health officer issued a circular letter to 25 manufacturing establishments having such dual systems, warning them that the river water was unfit for drinking purposes and indicating their responsibility in case infection occurred, if such water was made available to employees without notice as to its dangerous quality.

WASHINGTON, D. C.[2]

The evidence is very strong that tap water was the chief factor in the spread of the infection to the group of nine cases occurring among the residents or frequenters of the southeast section of the city. These nine cases were in persons who either worked at or resided in or visited daily the immediate vicinity of an industrial plant located near the Anacostia River, and obtained all or a large proportion of the water they drank within the 30 days prior to onset of their illness from taps either at or nearby this plant. The dates of definite onset of illness in these cases were as follows: One on December 10, two on December 12, one on December 17, one on December 18, one on December 19, one on December 24, one on December 28, and one on December 29. All very probably became infected within a period of a few days—possibly on the same day. About November 25, persons using the tap water in this vicinity, which comprises about seven city blocks, noted that the water was somewhat turbid and offensive to both taste and smell, and the management of the industrial plant reported the condition of the water to the District water department. Within the next 48 hours, diarrheic attacks, typical of so-called "winter cholera," were highly prevalent among the residents of the vicinity. The water department found upon investigation that the most probable explanation of the pollution of the water was inadvertent pumping of raw water from Anacostia River into one of the city water mains. So far as could be ascertained, it seems that an engineer at the industrial plant had opened the valves and made the pipe connection in order to use the city water in place of the raw water from the Anacostia River supply, and that his relief, coming on duty later the same night, without knowing the valves were opened, started the pump

[2] Reprinted by permission from Supplement No. 50, Public Health Reports, 1924-25, "A Typhoid Fever Epidemic Caused by Oyster-Borne Infection."

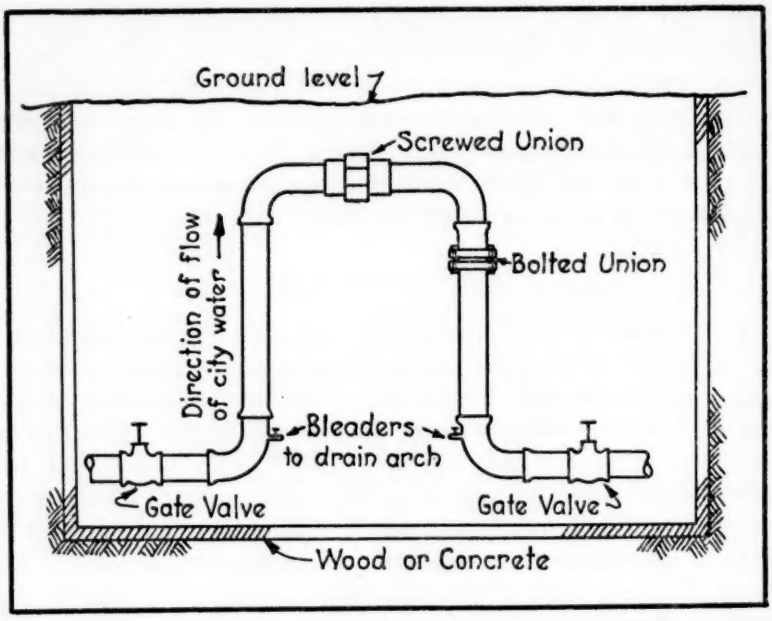
Ground level
Screwed Union
Bolted Union
Direction of flow of city water
Bleaders to drain arch
Gate Valve
Gate Valve
Wood or Concrete

FIG. 1

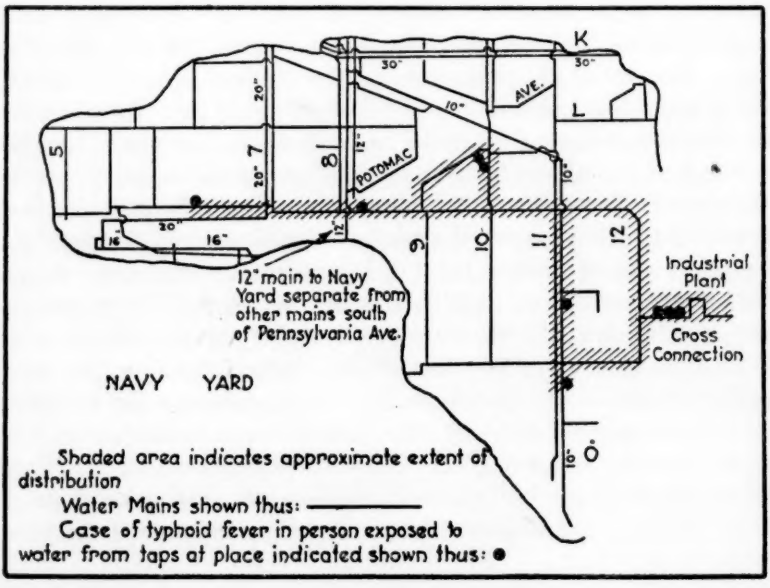
K
L
30"
30"
AVE.
10"
20"
20"
12"
POTOMAC
10"
5
7
8
16"
30"
16"
12"
9
10
11
12
12" main to Navy Yard separate from other mains south of Pennsylvania Ave.
Industrial Plant
Cross Connection
NAVY YARD
16"
Shaded area indicates approximate extent of distribution
Water Mains shown thus: ———
Case of typhoid fever in person exposed to water from taps at place indicated shown thus: ●

FIG. 2

which had power to overcome the city water pressure and thereby forced the raw Anacostia River water into the city main.

Figure 1, based on data furnished us by the District water department and the management of the industrial plant, shows the then arrangement of the valves and the mains, and figure 2 shows the course the polluted water from Anacostia River would have taken in this limited extent of the city water mains. The District water department had changes made at once in the system to preclude the possibility of another such accident.

The epidemiological histories of this group of cases in the southeast section stand out in sharp contrast in many respects to those of the cases in the other sections of the city, and indicate that the principal factor in the spread of the infection to these cases was separate and distinct from that which was principally operative among the persons in the northwest section of the city where the majority of the cases composing the excessive prevalence or outbreak proper occurred.

TREATED WATER IN SWIMMING POOLS[1]

By F. H. Stover[2]

There is an old adage to the effect "Give a dog a bad name and hang him," and in many instances this seems to be the attitude of the public, especially of the uninformed portion of it, toward waters which they know have been treated in any way.

A considerable portion of the population will very complacently use swimming pools in which the water is subjected to no purification at all, but thanks to the watchfulness of the various public health authorities the untreated pool is becoming more and more of a rarity, and it is to be hoped will soon be entirely extinct.

Once the treatment of a pool is begun various complaints, imaginary and otherwise, are often heard. Claims that the "chemical" causes smarting of the eyes, nose and even of the skin are sometimes made, even when very moderate doses are applied.

In some instances these complaints may have some basis of fact, as apparently some individuals are very sensitive to the chlorine, but on the other hand many persons will experience a similar smarting of the eyes if they are opened under water when swimming in natural streams. That many of these complaints are purely psychological and of an imaginary nature is shown by the fact that, if the pool be left untreated for a day or two, many of those using it, especially if questioned, will complain of the above mentioned symptoms, simply because they think the pool water has been treated.

About three or four years ago the writer installed a hypochlorite purification plant on a swimming pool operated in connection with a summer amusement park. It was found that a dosage of about 0.75 part per million of available chlorine gave a satisfactory purification and the apparatus was therefore operated at this rate.

After about a month's operation word was received from the manager of the pool to the effect that the owner had ordered the

[1] Presented before the Water Purification Division, Louisville Convention, April 29, 1925.

[2] Chemist, Louisville Water Company, Crescent Hill Filter, Louisville, Ky.

operation of the installation stopped as the towels and bathing suits used at the pool were being destroyed by the action of the chemical.

Investigation revealed that the laundry operator of the concern had been the discoverer of the alleged source of the trouble and an examination of some of the suits and towels revealed the fact that a lot of them had been so weakened as to be on the point of falling to pieces.

A closer examination of the deteriorated articles however showed that they were thoroughly saturated with a "high power" washing compound which was being used in liberal quantities in the laundry and which due to insufficient rinsing was not being removed from the fabric.

Substitution of a flake soap for the washing compound and an increase in the number of rinses promptly eliminated the difficulty which was thus shown to be a fault in the laundering and not in any way attributable to the treated water.

Another instance in which the bugaboo of treated water has been used to offset defects of manufacture has in two or three instances been called to the writer's attention by persons who after purchasing bathing suits have had them develop holes, in some cases after being used only a time or two.

On making a claim for adjustment against the merchant from whom the suit was purchased they were met by the argument that it was not a defect in the material which had caused the trouble, but that the difficulty was caused by the action of the chemical used in purifying the water of the swimming pool.

Inasmuch as the concerns operating all of the pools involved owned large numbers of suits which had been used continuously for from one to three years in some instances, without developing any such defects, the fallacy of this argument is at once apparent.

The illustrations cited above, while of a negative character so far as indicating deleterious effects due to treated water, do nevertheless indicate the desirability of following up such claims and placing the blame where it rightly belongs.

ALUM FLOC: WHAT IS IT?

By William D. Hatfield[1]

The thoughtful water works chemist is always intensely interested in learning the true chemical reactions on which his work is based. Not long ago we were taught that aluminium sulfate was decomposed by the natural or added alkalinity of water and that aluminium hydrate was formed according to the equation,

$$Al_2(SO_4)_3 + 3Ca(HCO_3)_2 = 2Al(OH)_3 + 3CaSO_4 + 6CO_2$$

in natural waters; or according to the equation,

$$Al_2(SO_4)_3 + 3Ca(OH)_2 = 2Al(OH)_3 + 3CaSO_4$$

when lime is added to furnish the lacking natural alkalinity.

The practical water works man soon found that these reactions did not tell the whole story. Other factors were at play and his hope lay in knowing his particular water and applying alum in that quantity which gave him the desired results. This quantity usually had no direct connection with the theoretical equations given above. However, the wide-awake water chemist was not satisfied with this rule of thumb method and has been seeking the true laws that govern coagulation.

Work on hydrogen ion concentration in other fields was so productive of results that within the last few years the water works men have turned their efforts in this direction. Studies on the hydrogen ion concentration in coagulated waters have shown that the point of most rapid coagulation was quite definitely controlled by the pH of the solution, and also that there was a broad pH zone within which the effluent from filters contained no dissolved aluminium (residual alum).

These were great steps in advance and the proponents of pH felt that the problem was at least near solution. Similar work was taken up all over the country and the results soon showed that the pH

[1] Superintendent, Disposal Plant, Sanitary District of Decatur, Decatur, Illinois.

value for most rapid coagulation differed with different waters. The same was true with the broad zone of insolubility of aluminium. Each water seemed to have characteristics all its own. From a practical standpoint these differences were not large, but they were sufficient to show that there were other factors along with pH to be considered.

The recent work by Clark, Theriault and Miller of the Hygienic Laboratories, United States Public Health Service, is one of the most important contributions to our knowledge of "alum floc," its composition, and the factors which govern its chemical and physical properties. This work is published in six reprints from the Public Health Reports, and may be obtained from the Government Printing Office at Washington, D. C. The numbers of these reprints and the titles are,

No. 813. An experimental study of the relation of hydrogen ion concentrations to the formation of floc in alum solutions. (1923.)
No. 862. On the composition of the precipitate from partially alkalinized alum solutions. (1923.)
No. 932. Adsorption by aluminium hydrate considered as a solid solution phenomenon. (1924.)
No. 992. A study of the effects of anions upon the properties of alum floc. (1925.)
No. 1023. Some properties of iron compounds and their relation to water clarification. (1925.)
No. 1028. Notes on the clarification of colored waters. (1925.)

It is the purpose of this paper to briefly review the conclusions of these papers in the hope that water works chemists in general will acquaint themselves with the originals.

The foundation for the studies reviewed below is laid in the well known pioneer work of Clark and Theriault reported in Reprint No. 813. During 1922 and 1923 numerous investigators were studying the effect of hydrogen ions on the coagulation of natural waters by alum, but the very excellent quantitative data reported by Clark and Theriault brought thought from generalities to more definite and specific conditions. The summary of this ground work is taken verbatim from Reprint No. 813:

The outstanding features of the results of this study are as follows: The hydrogen ion concentration of the final mixture of water and alum is of fundamental importance in the formation of floc. When other possible factors are left out of consideration, the optimum conditions for the floc formation will be found with a narrow zone of pH centered for dilute solutions at pH 5.5. The more dilute the water in total salt content and the less the alum added the

narrower becomes the pH zone with which optimum floc formation is to be found. Consequently, precise pH control should in favorable cases permit of great economy in alum dosage.

In the second reprint from the Hygienic Laboratories, Miller shows that alum floc is not aluminium hydrate ($Al(OH)_3$) except as a limit to be approached as the pH of the treated water approaches 8.5. At pH values from 4.0 to 5.5 the floc is a basic aluminium sulfate which approximates the formula $5\ Al_2O_3 \cdot 3SO_3$. As the solution from which the floc is precipitated becomes progressively more alkaline the percentage of sulfate in the floc decreases to zero at pH 8.5. At this point the floc is our old friend aluminium hydrate.

From a practical standpoint this means that the floc in all waters having sufficient natural alkalinity is a basic sulfate, the proportion of sulfate increasing as larger quantities of alum are added (or as the pH decreases). As we approach neutrality to methyl orange (pH 4) the floc has the approximate composition of $5\ Al_2O_3 \cdot 3SO_3$.

When lime is used with alum to produce artificial alkalinity, and the alkalinity approaches the faint pink to phenolphthalein (pH 9) the composition of the floc will be $Al(OH)_3$.

This paper also confirms the earlier work of Baylis[2] and Hatfield[3] which showed a broad pH zone in which the aluminium is practically completely precipitated from solution, and no residual alum should be found in filter effluents.

The third reprint shows that the complex basic sulfates of aluminium act as a solid solution in which the sulfate is replaceable by other polyvalent negative ions in the solution. This replacement is similar to the way in which sodium is replaced in permutit by calcium and magnesium. Monovalent ions such as chloride are shown not to replace the sulfate in the floc. The work, however, would have been more complete from a practical point of view if it had demonstrated that the bi-carbonate ion was also without effect. The bicarbonate ion is the most prevalent monovalent ion in natural waters. The only polyvalent ion normally present to any extent in natural waters is sulfate so the replacements mentioned above will probably not be of consequence. However, waters that are treated with soda ash may contain the bivalent carbonate ion, and therefor

[2] Baylis, J. R., The use of acids with alum in water purification and the importance of hydrogen ion concentration. Journal, May ,1923, page 365.

[3] Hatfield, W. D., Hydrogen ion concentration and soluble aluminium in filter plant effluents. Journal, May, 1924, page 554.

it would be interesting to extend Dr. Miller's work to the replacement of sulfate in the floc by carbonate instead of oxalate.

This replacement, however, suggests a new line of study on the mechanism of color removal. It is shown that dyes having one acid group did not replace sulfate in the floc, but that dyes having two or three acid groups were adsorbed by the floc with the replacement of sulfate. It will be remembered that high colored waters are usually coagulated at low pH values, and Miller has shown that at these low values the alum floc contains the largest percentage of sulfate. The question of color removal is more completely discussed in the later Reprint No. 1028.

In the fourth reprint the importance of the negative ions in solution on floc formation is emphasised. It is shown that the pH at which most rapid floc formation is obtained may be varied at will by changing the kind and concentration of the negative ions in the solution. The broad pH zone of complete aluminium precipitation may also be varied by the anion content. These results serve to explain the reasons for the variable result obtained by different investigators on the region of pH over which flocculation occurs in water purification and the region within which soluble aluminium is absent from filter effluents.

The work at the Hygienic Laboratories indicates at least three factors necessary to successful clarification of waters by alum; (1) there must be added a certain minimum quantity of aluminium ions; (2) there must be present an anion of strong coagulating power such as sulfate; (3) the hydrogen ion concentration must be properly adjusted. In buying alum the water works superintendent purchases two values; a potential supply of aluminium ions which react with the alkalinity of the water to form an insoluble material and a potential supply of sulfate ions, which of all ions studied have the greatest power to coagulate this insoluble material into flocs.

This would indicate that the specifications for alum should allow the greatest possible percentage of sulfate that is practical. I am told by manufacturers of alum that it is impractical to make an acid alum because it is hydroscopic. However, it would seem that the basicity should only be enough to overcome the absorption of moisture. Of course, where the alum is made at the plant by the Hoover method the acidity and sulfate content may be adjusted at will.

In the fifth reprint studies of the flocs formed by ferric chloride,

ferric sulfate, and ferrous sulfate are presented. The conclusions are the same as those for alum except that (1), ferric floc differs from alum floc in the fact that it does not dissolve at higher pH values and therefor less careful adjustment of pH is required and (2) ferric floc begins to form at somewhat lower pH values than does alum floc, which may be of advantage under certain conditions. The absolute necessity of the presence of coagulating ions such as sulfate ions are again emphasized.

From the sixth reprint on color removal, I take the liberty to quote verbatim the following paragraphs;

> The experiments described in this paper suggest a conclusion which, if found by future work to be of wide application to colored waters, will be of considerable significance in the commercial clarification of these waters by alum. In the clarification of the colored waters studied it is the strong coagulating power of the trivalent aluminium ion acting on the negatively charged colloidal "color" which is of importance. It causes the formation of what may be called a "color floc." "Alum floc," which is of so much importance in other aspects of clarification, plays an unimportant rôle. In fact, the formation of "alum floc" by its removal of aluminium ion from solution in the form of an insoluble compound would be distinctly antagonistic to the formation of the "color floc." All conditions, therefore, such as proper hydrogen ion concentration, which would otherwise tend to retain the aluminium in solution in the form of aluminium ion, will tend to promote coagulation of these "colors."
>
> This leads us at once to the fundamental question of the proper range of hydrogen ion concentration for best results. It has been shown (see Clark and Theriault, 1923; Miller, 1923; Baylis, 1923; and Hatfield, 1924) that from the acid side the precipitation of alum first approaches completion near a pH value of 5.4. Above this approximate value precipitation and removal of aluminium ion from solution is practically complete. Below this value aluminium ion as such is retained in solution. It is above this pH value therefore, that best clarification of turbid water results, because of the clarifying action of "alum floc."
>
> In the literature of the last few years on this subject, abundant evidence exists confirming this conclusion. Similarly it is below the pH value of 5.4, where aluminium ion exists as such, and there clarification of highly colored waters of the type under discussion should occur. Definite information upon this point from commercial sources is almost entirely lacking with the exception of the results of Norcom (1924) on Cape Fear River water. These point to the same conclusion. Information, however, is entirely too meager to consider this point as universally established.
>
> While a low pH value seems to favor formation of the "color floc" by alum, this fact may prove to be one of the difficulties of the method when applied to water purification. In the coagulation of coloring matter a part of the aluminium ion will probably be removed from solution by adsorption or combina-

tion with the color material. Since the pH of the water must be raised subsequent to the coagulation because of its corrosive action at low pH values, it is highly probable that flocculation of the remaining alum will occur at this point. Norcom (private communication) states that he has observed this to occur especially during the winter months. He has avoided the difficulty by connecting his sedimentation basins in series, treating the water with alum at a low pH value in the first basin and increasing the pH in the second basin by the addition of alkali.

In the above review the author has not tried to cover the literature on alum floc, but has tried, at the request of the Editor, to bring the very excellent work of the Hygienic Laboratories before the practical filter operator in a semi-popular way.

SUPERINTENDENTS' QUESTION BOX SERIES[1]

PLANNING FOR THE FUTURE

MR. DOW R. GWINN: The most interesting experience I have had in the water works business in recent years was when we arranged with Alvord, Burdick & Howson, to make a report of the needs of the Terre Haute Water Works Plant for the next fifteen years. If any of you have not done something of that kind in recent years, I advise you to do it. We thought we knew something about it, but when a man comes from the outside who is thoroughly competent and begins to look over a plant, he sees where the weak points are and what you are going to be up against. They took our consumption back for a period of years and made a chart showing the probable consumption fifteen years from now, and figured how many pumps we would need to take care of that, and they went at it in a very systematic, scientific way. The result was a book of 100 typewritten pages telling us what we should be doing.

One of the first things we had to settle was what would be the future source of supply. For many years the water had been taken from the Wabash River, but there is an unfailing supply of ground water there. Somebody might say, "Fifteen years hence, why didn't you pump ground water instead of spending a lot of money for filters? The ground water is here." So we put in a test well about 8 inches in diameter, put in a temporary pump and got a Fordson tractor to operate the pump, and put on a meter so we could tell what the flow was. We then put down test pipes around the well at different distances from the well so as to determine how much of a drop there would be, and we operated the pump for two weeks, night and day. We found that from an 8-inch well we could get easily half a million gallons a day, but we made tests for hardness and found it much harder than the Wabash River water, and that is saying a lot. Well, that would not do. Then they figured up what it would cost to soften well water. Of course, the harder the water the more difficult it is, so they concluded they'd better soften the Wabash River water,

[1] Presented before the Louisville Convention, May 1, 1925.

because it would not cost so much to do it. They went over the whole thing from A to Z and we gave them a check for their work.

About that time Mr. Goldsmith, of the Underwriters, came down to see us, and made a survey of the town, and they made their recommendations as to the feeder mains we would have to put in. We got through and figured it all up and found that it would cost about a million dollars to put in what had been recommended. It did not seem to bother them at all; to dig up the million dollars, was our problem; but it is worth while to have somebody from the outside who understands the thing to make a survey of your plant; it will save you money before you get through, because you'd better work to a general plan than stand around, hit or miss. I just suggest that to you as something that was very interesting to me, and I am sure that if some of you would follow the same plan you would find it interesting and worth your while.

TUNNEL CONSTRUCTION IN THE WATER WORKS OF ST. CATHERINES

MR. ALEX. MILNE: In the construction of a duplicate main (24-inch) from the reservoirs at De Cew Falls to the City of St. Catherines, in order to avoid very heavy rock cutting to obtain hydraulic grade lines along a rough, heavily timbered section of the mountain side, it was finally decided, after a thorough investigation of the character of the rock, etc., to drive a tunnel in a direct line from the reservoirs to the point connecting the main to the city.

The rock tunnelled was a close grained grey limestone in a vertical stratum averaging about 7 feet in thickness, under and overlaid by heavy horizontal limestone.

The tunnel was made as small as the radius of the drill operation would permit, viz., 5 feet, and with the average break of the rock gave an opening averaging 6 feet in width. No seams were found during the operations and when the tunnel was completed and cleaned out a bulkhead and shaft was built at the intake end—with a 30-inch valve in the bulkhead to form a blow-off to the nearby ravine—and at the discharge end flanges were cast into the concrete for two 24- and one 36-inch pipe connections. No lining was used, and while there was a small leakage for a short time at the discharge bulkhead, it very soon silted up, and is dry now after ten years use. The saving effected by the tunnel as against the pipe line along the original route proposed was estimated at $68,000 and the tunnel is amply large enough for the additional 24- and 36-inch connections when required.

METER TROUBLES

MR. HARRY F. HUY: One of the interesting things that happened in our plant during the last year or two was that we commonly describe as a bootlegger's meter. The reason we gave it that name was that it was a service that had water bills running from $250 to $350 or $400 a quarter; the man paid the bill without any question as to the accuracy of the meter. All of a sudden we found that we owed the man money; the meter reader went back and checked the reading and found that we owed him still more money. The foreman went back and he also found that we owed still more money and so they called me up and the foreman said "I watched this meter; this meter does not run in the right direction. It hesitates; turns around and runs backward." I said, "I know how it is, you were in the wrong place when you got down there; instead of being in the cellar, you were upstairs."

The meter was taken to the shop and put on the proving bench to see what the trouble was. The foreman of the meter shop reported just what the meter reader had reported. Upon examination of this particular meter, we found that due to the large use of water through the meter, the train gear had worn to such an extent that the bearings were oblong, and when the meter was in a quiescent state, the gears adjusted themselves so that when the water flowed through them at a high rate the gears unmeshed and drove the main gear in the opposite direction, causing a negative registration. When the meter was running lightly loaded, it rotated in the right direction, but when the big load came on it, it ran in the opposite direction.

We lately had a similar condition where a compound meter would run backwards on the low flow meter. Due to turbid water, we have to keep the small meter on a compound meter working all the time, and we have so arranged the meter that it does; otherwise it gets filled with sediment and does not work at all times.

We have a railroad service in the yards which has six or seven connections from the main line into the different sections of the yard. Two of these are very closely connected to a tank. We found that, when the tank was closed off, the small meter ran backwards, which was due to the pressure coming from some other meter nearby, just enough to cover the friction losses between the two meters so that the particular meter ran backwards part of the time. That could be remedied by a check valve.

CLEANING INTAKE PIPES

MR. HARRY F. HUY: Some nine or ten years ago we constructed an intake pipe line, the second intake from Lake Erie. The first intake was constructed twenty-five years ago, due to the ice shifting the intake crib on the old intake pipe line and there was not sufficient water delivered through the original intake. After the new intake pipe was constructed and they had plenty of water and paid no attention to repairs to the old pipe line, because it was hard enough to pay the interest and operating expenses at that time and no repairs were considered until they reached the stage where they had to have additional water. At this time a new concrete intake crib was installed on the old line, extending 6000 feet out into the lake. It was assumed we would have to take up 150 or 200 feet of the old intake pipe and clean it. Upon examination, after actually starting work and taking up the first 150 feet, we found that it was entirely filled with fine silt. Indications showed that this silt continued into the intake about 1500 feet, and after thinking over how best to remove the silt, I happened to be listening to the talk of the dock men employed on the work. It sometimes pays to listen to a man who is not an expert; he has an idea that is often a good one. This dock man said, "Why don't you put ice through that intake and clean out that mud?" I started to smile at first, and I happened to think and asked him what he knew about such a plan. After learning his experience we made arrangements to buy some 80 tons of ice and started out with a piece about 18 inches square, sending it through the pipe line. Turbid water showed in the well at the pumping station, and on the completion of the work, we had exactly the same friction losses as through a new pipe.

PITOMETER SURVEYS

MR. W. S. PATTON: I wonder whether it is a good idea to make your own survey or get a regular company to take charge of it. I would like to know if anyone here had made any cantonment surveys, and whether or not they have pitometer surveys, and made a record? I understand that in Pittsburgh they make a pitometer survey every year. That looks to me awfully expensive. I would like to have one in my town. I wonder whether it is feasible to buy a pitometer and make it myself or get a pitometer company to do the work.

MR. G. C. GENSHEIMER: We had a survey and it was followed up by the purchase of a pitometer. In Detroit they have a company making these pitometer tests all the time.

MR. HERSCHY (of Wisconsin): About three years ago we had a pitometer survey made, and while we have not followed it up, we have kept pretty close check on our meters and also checked our small and large meters against the venturi-meter. I believe in a large plant where you have a considerable investment to spread over the cost of your pitometer survey, it ought to be followed up. Every two or three years, possibly, it ought to be re-surveyed. In most large cities, the city can afford to have the equipment to make the survey. It is a good time right now to emphasize the necessity of a survey or check-up of some kind. In making this survey we found practically all of our waste in one particular meter. It was a large meter; that is the waste on which the pitometer surveyors collected their money. Our mains were absolutely tight and there were only a couple of leaky services found. Even though this particular leak the pitometer people found was due to under-registration of the meter, we figured it was well worth the money. After they got through, we sat back with the satisfaction of knowing that our mains were intact and that our system was intact, which is well worth what you pay, even though no leak is found.

MR. BROGAN (of Detroit): We had the town crew, previous to the installation of this filter plant. We thought well to close all gaps.

We were using considerable water, and legitimately so in a great many cases but we found the benefit from the survey so great that we installed a special department, a survey department. The point I wish to call attention to is the fact that, resulting from this survey, the Board adopted certain rules as to size of meters to be supplied by the consumer. It so happened that the pitometer company, in making up their sections of the city, struck a section where there were 14 apartments in the building. They found a night flow of less than four gallons in the 14 apartments, and the analysis of the survey immediately showed this small night flow. The result was that the Board adopted certain rules by which they would only install meters up to a certain size in certain size houses. In that way we accepted the loss of water through non-registration. The apartment house had a 3-inch meter, and now it has a 1½-inch meter and consequently measures the flow much better than the large one did.

MR. W. S. PATTON: At Ashland, Kentucky we have very interesting experiences from plotting the daily consumption of our large meters and we find that a graphic chart showing the daily consumption of the large industrial consumers requires very little effort and gives us a good grasp of the requirements of the consumer.

The cost of plotting the daily consumption is slight but the financial returns are wonderful. For instance, a new consumer wanted a 3-inch connection and meter. The meter applied for was installed.

After we had started the plotting of daily consumption of our large consumers we noticed that the curve of the consumption of above consumer showed that he was taking only a little more than the minimum quantity of water. He had a compound meter.

We examined the outlets at his factory and found that no large flows of water were required so we removed the 3-inch meter and gave him a 2-inch meter. As a result his bills almost trebled. The 3-inch compound meter was too large for its purpose and for some reason the disk meter had not been registering accurately, but by reason of the graphic chart the need of attention was so obvious that the meter received immediate attention, whereas under a less close supervision a meter of this kind might under-register for a year or maybe two years before detection.

I have a high opinion of the value of graphic charts in the water works field and I wish to commend their use to other water works men. I have always found that no one seems to have the time to go over the daily readings of the large meters and to draw conclusions.

As a general thing I find that the tendency is to wait until the meter ceases to register before changing the meter. A periodic test reveals slow registration, but does not help the operator to determine the best size or type of meter for a given purpose. There are too many misfit meters with a corresponding heavy loss of revenue and the graphic chart is the obvious remedy.

At my plant, my draftsman plots the daily consumption and lays the sheets on my desk. The first thing in the morning I glance through the sheets and with a moment's delay I know the daily pumpage for the previous twenty-four hours as compared to the sales to all large consumers and the amount of water sold to each consumer. My draftsman is interested in these curves and, if anything appears suspicious, the chances are that orders have already been issued to investigate that particular meter.

MR. HARRY F. HUY: You gentlemen have brought up a subject that is my pet hobby, to get paid for all the water that leaves the pumping station, or as much of it as possible. Seven or eight years ago I took charge of a company that was receiving revenue for 45 per cent of the water pumped from the main pumping station and the first thing we started out to do was to find out where the trouble was. We made a pitometer survey. Such a survey should be made by men who are well versed in the art, because they will do it with dispatch and get at the trouble very quickly. There is great possibility of error in the ordinary layman handling the pitometer instruments.

Most of the trouble was located in meters of under-registration. We had a type of meter which is admitted today to be obsolete by the manufacturer, but the water company had hesitated to change it on account of the great expense. Most large meters were removed and replaced by a compound type of meter. Upon the completion of the removal of some 200 of these meters, the percentage of accounted for water was brought up to 75 per cent; in other words, we received in actual dollars and cents about 75 per cent of the water delivered from the main pumping station. The next step was to remove and to test every house meter on the system, of which there were about 9000. On completion of the removal and repairing of all the domestic meters, we found many of them under-registering, and the revenue-producing water was increased to 85 per cent.

In connection with removing meters, we tested every house service and found a number of services leaking, which were repaired. Leak-

age on house services did not show up on the surface; the water was going into the sewer, which in the past had been laid in the same trenches with the water pipes. Our service pipes are no longer installed in the same trench as the sewer. After all the services were repaired and all house meters and all the commercial meters repaired, on a pumpage of ten to eleven million gallons a day, 92 per cent of the water was revenue-producing. For the last six years we have averaged 89 per cent paid for of the water leaving the pumping station.

In connection with this work we have established pitometer stations on main feed lines running in certain districts and, as soon as the percentage of accounted-for-water was decreased, the pitometer men measure the water going in any particular district, compare it with the meters and determine the rate of loss. Many years ago, if a community received pay for 70 per cent of the water they pumped, they were doing very well, but I always wonder where the other 30 per cent is. The answer given was flushing sewers and fighting fires, etc. It may be flushing sewers in some cities, if done in a wasteful manner; it is not fighting fires, because the actual amount of water used in fighting fires is very, very small. From records kept on our plant, the total amount of water used for fires all through the year on 180 miles of pipe line is less than 1 per cent of the water pumped.

MR. WM. LUSCOMBE: We find that the follow up system is a very good system to adopt in the setting and the registration of meters. Of course, when the meter is first set, we use our best judgment as to the size and type of meter that should be used for certain service, but it is more or less guess work. We use a follow-up system by analyzing the record of that meter for the first year or so, and we find it pays. Take the registration; the meters are read monthly and we of course even analyze what you might term the peak load demand made on the meter, that is, the more important meters. It has been our experience that we find often a two- or three inch-meter would be in a place where a meter of one-half or one-fourth capacity would do the work just as well, and perhaps in other cases where the meter is over-taxed; so, with the follow up system, it enables the operator to place meters more intelligently where they can work most efficiently.

MR. ROBERT B. MORSE: It occurs to me that, perhaps, in the case of those systems where the rate schedule contains the true service

charge and sufficient weight is given, in making up the service charge, to the water which passes unregistered through the meter, the importance of cutting down the size of the meter to an absolute minimum may not be so great as elsewhere. In our case, for instance, the service charge for an 8 inch compound meter is $300 a year, while that for an 8-inch fire line meter is $360 a year. This difference in the schedule is based on the theory that somewhat more water, in general, will pass unregistered through a fire line meter than through a compound meter.

Our service charge is made up of a 10 per cent charge on the cost of the meter, covering the depreciation and fixed expense; a small item for reading the meter, billing, etc.; and a third component, the largest, which is designed to take care of the cost of water which will pass through the meter unregistered. I recognize that, if a smaller meter can do the required work, more of the water which actually passes can be registered and you will receive a larger payment on the consumption charge, but at the same time your service charge receipt will be less. As the amount of water used on the premises is not dependent on the size of the meter, a schedule in the service charge is sufficient factor for unregistered water, decreases the importance, from the standpoint of income, of discouraging the use of meters of larger size than may be actually required.

MR. HARRY F. HUY: The point in making a service charge, assuming that you put any size meter in, if they are willing to pay the service charges, is that in a compound meter there is a point of change-over in the valve from high flow to low flow, where the registration of accuracy is only about 90 per cent and you reach that balancing point very often; your low meter changes at about 5 pounds friction loss, so there is a point in that type of meter where they will only register 90 per cent of the actual consumption. They might have a 10-inch meter to get on that balancing point and lose 20,000 gallons of water per day. We do not have a service charge, but we have a minimum charge for large quantities of water, and if a man wants a 6-inch meter, he has to agree to take at least 200,000 gallons of water a day. Using over-size meters has a tendency to under-registration of actual water consumed.

MR. ROBERT B. MORSE: It is hard to provide a large service charge to take care of such conditions as that, but you can go a long way toward it.

MR. CHILDS (of Philadelphia): I would like to bring to the attention of the members here this afternoon several experiences that we encountered in Philadelphia in the operating line in the summer of 1923. The first experience was due to extremely hot weather. During the month of June 1923, we had severely hot weather in Philadelphia, so hot, in fact that the people in the crowded districts slept outdoors all during the night and fire plugs were turned on continually, not by any authority but by children who wished to slosh around in the water. If my good griend from Holyoke was here, I suppose he would have to have a policeman for every fireplug, but as soon as the policeman turned off the fireplug in one square, the children ran to the other and opened that, so it was absolutely impossible to control the waste of water.

All filter plants and pumping stations were running at over-capacity—I mean to a considerable extent. If you take a slow sand filter plant and run it anywhere from 20 to 30 per cent over the capacity for which it was designed, I believe that is considerably over capacity. Now the pumping stations were in a similar condition; it was absolutely impossible to shut down boilers or pumps to make any repairs whatever. The first day or first twenty-four hours, it was all right; we hit it up for all we were worth because we did not think the hot spell would last very long, but after the first twenty-four hours had passed and there was no relief in sight, it was apparent that we would have to take drastic measures to prevent this waste of water. It is an unusual condition in Philadelphia where people are allowed to sleep in Fairmont Park, and that was the first time for a number of years that such a condition was allowed to exist, due to excessive heat.

We finally came to the conclusion that the best thing to do was to simply set a safe maximum for all pumping stations and filter plants and to make our distribution division take care of all excessive drafts on the distribution system. That was simply done by throttling down on the valves that controlled our main feeder and allowing the people to get so much water and no more, because our reservoirs

would have been entirely empty, if we had allowed conditions to go on as they existed at that time. Now, the moral effect upon the people was not as we thought it would be. We thought that the people would severely criticize the Bureau, but instead of that it brought to their attention the fact that they were unduly wasting water.

The second topic I would like to bring to the attention of the members here is that, during the spring of 1923, on one of our filter plants, we developed in the effluent in one of the filters, a very bad odor and taste. Now I might say, before I go on with that, that during that period of the year we always have a very low draft on the system, that is the spring of the year, the people are not using the water they use in the summer or the winter, so that the filters are all running at a low rate. Some of the samples of the effluent from this one filter were taken to our laboratory, but from our examination we could not find anything in that water that would indicate the cause or source of the trouble. From the bacteriological and the chemical and microscopical standpoints, we did not find anything in that water that would indicate the cause of the trouble. Yet inside of ten hours the effluent from that one filter plant had, I might say, polluted the entire supply in the reservoir so badly that it was only a very short time before the people throughout that section of Philadelphia were calling up and wanting to know what was wrong with the water. You could smell that filter before you got to it; it had a very bad odor and taste.

The question then occurred, why was it concentrated at one filter? It was not long, within several hours, that the men reported that another filter was doing the same thing. After examination by the laboratory, we decided to drain the effluent chamber and see whether there might be anything in that chamber that would be causing that trouble, because the odor was exactly like decayed animal matter. We thought it might be a cat or a rabbit or some animal that got into the chamber and decayed, but upon examination we found nothing to indicate the trouble. We even opened the sand run doors and looked into the filter, and there was no odor that came from the surface of that body of water. It was perfectly all right in that particular filter, and yet in the effluent chamber it was very strong. We drained the chamber with the idea of looking over the surface of the sand to see whether any foreign matter had got into the ventilator, but we could not find anything that would indicate the trouble.

Our next step was to take samples of the sand; we have about 36 inches of sand in our slow sand filter, and throughout the various portions of the bed we took samples, but the sand did not indicate the odor, so we were at a loss to know what was causing it, and, more than that, how to eliminate it. We were all satisfied that it was there.

We came to the conclusion that possibly it might be some growth or something in the underdrain of the filter, and the fact that it might be organic, it would be possible to eliminate that by oxidation. Now, the fact that the filters were running at a slow rate gave us the idea that possibly we did not have sufficient oxygen in the form of air going through those filters, that is, contained in the water, so what we did was simply to take one of these filters and double its rate, increasing it from 3,000,000 gallons a day to about 6,000,000 or 7,000,000 gallons per day to see what the effect would be. Inside of 7 hours, that entire odor and taste had been removed from that particular filter, and the same process was tried on several other filters that had odor and taste. In less than twelve hours there was no filter that had any odor or taste whatever. Of course, then it was just a question of time until we used up the water in the reservoirs and inside of one day all complaints from that quarter had ceased. I would like to know whether any operators in filter plants have had similar experience?

MR. HARRY F. HUY: Was any examination made of the sand to see whether there was any vegetable growth therein?

MR. CHILDS: We took samples of that sand to the laboratory and could not find anything that would indicate the source of the trouble, and I might say that it is the first time in twenty years that such a thing actually occurred and we have not had it since.

MR. HARRY F. HUY: Did the water analyze all right?

MR. CHILDS: Absolutely; the laboratory did not detect a thing, either by the microscope or bacteriologically or chemically in that water.

MR. HARRY F. HUY: Do you continue to operate those filters at the high rate?

MR. CHILDS: We did for about three days, and after that went back to normal operation and have not had that source of trouble since, but I feel that it was just a question of purification.

MR. HARRY F. HUY: Did you attempt oxidation before at all?

MR. CHILDS: No sir.

MR. HARRY F. HUY: Is there any other discussion on tastes or odors?

MR. R. F. WAGNER: It seems to me as though the trouble might have been originated by the growth of pipe moss in those underdrains, which may have flushed out when you increased your rate. I merely offer that as a suggestion; I have had an experience in that line.

SIZES OF SERVICES FOR FLUSHOMETERS

A MEMBER: I would like to have the benefit of any helpful suggestions of any representative of a utility company or a municipality here, on how most satisfactorily to handle the matter when customers make application for over-sized services in order properly to flush these so-called flushometer water closets? With us we are repeatedly called on for that service. I believe the manufacturers claim that an inch and a quarter service ordinarily is required to flush, and were it not for that type of closet $\frac{5}{8}$-inch service would suffice. We state the matter could be taken care of by the installation of storage tanks, but that adds to the cost and is not satisfactory to the customer. If there are any here who know how to handle it, I would be very glad to hear from them. Our local plumber has also suggested that a piece of pipe be inserted in the partition back of the closet that would contain sufficient volume of water to represent one flushing, and that the matter could be satisfactorily handled in that way, but we have not tried that method as yet.

MR. G. C. GENSHEIMER: We have had some experience, but we give them a $\frac{3}{4}$-inch tap lead service to the curb. If they want to use a flushometer closet they can increase their pipe, either from the curb or inside the building. That seems to have done the trick.

MR. HARRY F. HUY: What size feeder do you allow in that case?

MR. GENSHEIMER: We are not metered.

MR. HARRY F. HUY: No trouble arises on that arrangement as long as you do not have a meter, but when you get to a meter it is a different proposition. We are handling that at present by simply putting the question up to the man who builds the house, that he must pay a minimum of $9.00 for a six-room house and $1.00 for each additional room, which allows him a $\frac{5}{8}$-inch meter as the size of the dwelling increases, so that the minimum is $18.00 if we put in a $\frac{3}{4}$-inch meter. With an inch meter, the minimum is $50.00. The

ordinary house requires a $\frac{5}{8}$- or $\frac{3}{4}$-inch meter. When the flushometer man comes along and says "I want to sell this plumbing," we let the owner settle the question whether he wants to pay $9.00 or $18.00 or $50.00. We had the question arise because the Bethelehem Steel Company had an operation of 350 houses going up at one time and the flushometer people thought it was an excellent chance to put in the apparatus. They made a very low bid; and offered all sorts of inducements to the steel company to put in the flushometer; it would cost about the same as a tank closet, but they wanted an inch meter on every service. We made experiments for them and found that they could actually operate the flushometer valve on a $\frac{3}{4}$-inch service.

A MEMBER: At what pressure?

MR. HARRY F. HUY: About 80 pounds at the main. That is a governing factor, also; with a greater pressure they can use a smaller size pipe, but under the normal conditions you have to give them as large a service pipe from the main as they request, because many water systems operate with 20 or 30 pounds. I think the tank arrangement in the house is going to be the solution of the problem for those people who want the flushometer closet; no doubt they will have them, because they go to the hotels and see how nice they are in the bathrooms and when they build a house, they want that kind of an arrangement, rather than a box type. I think, rather than put the burden on the water company to furnish the meters which will be over-size to start with, the tank in the cellar or attic is the solution for their installation on small services.

A MEMBER: How big a tank will operate satisfactorily?

MR. HARRY F. HUY: The funny part is that they do not use as much water as the tank closet.

A MEMBER: How much is that?

MR. HARRY F. HUY: That is sometimes 2 gallons per flush, although generally from 3 to 4 gallons. The argument that the flushometer people use when they try to sell the apparatus is that

it uses less water than the tank closet, but they do draw at the rate of 25 to 30 gallons per minute on the service of the water company when they operate.

MR. DOW R. GWINN: It is quite a serious problem; if it requires 1½ inch or 1¼-inch to take care of the flushometer water closet, it would mean adding to the investment for the plants. A gentleman that had a bungalow which cost him $10,000 wanted the best of everything for his house. We put in a ⅝-inch service as usual for him up to the curb, but the plumber said, "This will not take care of this water closet." "What kind have you got?" "Flushometer." I said, "Our rules do not provide for anything of that kind; they provide for tank water closets." That made him scratch his head a little. He thought he would have to take it out. We said, "Let us see if we cannot find some way of fixing it for you." He said that he had a 1¼-inch pipe run to the curb. I said, "All right, carry that up to a point immediately under your water closet and install there a range bolier; make your connection at the bottom and run the water pipe up from the bottom to the water closet and provide a pet cock at the top and a valve below, so that when you run out of air, you can fill it up again." We never had a word of complaint from him afterwards. He had a large volume of water in the 30 gallon tank, and when the water closet was released, the air pressure forced water up through the closet. He was going to put the tank up in the attic, but he did not heat it in the winter and there was danger of its freezing up; so he put it down in the basement immediately under his closet and it worked all right. Once in a while he put fresh air in it. It worked all right and saved putting in a large service pipe for him.

MR. POWELL (of Griffin, Ga): I think Mr. Gwinn had the right solution to that. We had a few of those flushometers. The first that got in, got in on a ⅝-inch tap. Wherever they were used we always recommended the use of a tank and never had any complaint on any of them.

A MEMBER: Before you leave this subject, I would like to ask what practice the gentlemen follow where you have a large number of these flushometer closets on each floor, say at a public school, and the children all come out from the classroom at the same time and every closet is used, one after another? What size service and what size meter do you install with ordinary pressure?

MR. HARRY F. HUY: We connected to our mains a number of public schools in the last year or two and they all have a number of flushometer closets, possibly twenty or thirty. The architect in that case had specified 2- and 3-inch connections, so that covered the service situation. The closets draw at the rate of 25 to 30 gallons a minute when they are operating. Even though they operate only momentarily, there may be five or six operating at a time, which draw at the rate of 150 gallons of water a minute.

A MEMBER: Do you get a water hammer with them?

MR. HARRY F. HUY: No, they operate satisfactorily. We had one in operation in one of our pumping stations at Niagara Falls since 1911. There is some slight hammer but not enough to affect the main. A committee has been appointed to investigate the question of flushometer closets and I presume by the next meeting we shall have a report. They are endeavoring to collect data at present. I think your discussion will be very apropos to their investigation.

MR. DOW R. GWINN: We had another case where there was a four story building. They wanted to put in the flushometer water closets. We supplied a 2-inch meter and they paid at the minimum rate of $5.00 a month. If anyone wants a large connection and finds that it costs more for his minimum rate, he loses his enthusiasm.

A MEMBER: We had a recent installation where a new hotel, with about 80 rooms and about the same number of flushometer closets were installed. They had the matter up with us and recommended the installation of a storage tank and wished to know the capacity. I asked them to take it up with the plumber and the architect and the manufacturer. The next thing I knew they made an installation of a storage tank measuring 4 feet in diameter and 8 feet in length to take care of the deficiency in the water flow. The hotel is not yet in operation, so I do not know what the success of that is.

MR. WARREN C. MILLER: In last year's proceedings[1] of the Association there was a discussion of this same order where some gentleman said he had made a practice of using a tank of 14 to 15 gallons per fixture capacity to include both air and water. Possibly that figure might help in determining the size of the tank.

[1] JOURNAL, November, 1924, page 312.

RULES AND REGULATIONS GOVERNING PLUMBING

MR. E. E. NORMAN: In Kalamazoo we have, for years, tapped the main and run a service to the sidewalk. At the present time a plumber runs a service into the house and does the rest of the plumbing and we get the meter. We keep close check by inspecting the service, but we cannot say it is satisfactory. We have to keep too close a tab to get any kind of a ship-shape job done. In many instances we think the plumbers are overcharging the customers. In one instance the plumber bought lead pipe of us for 38 cents a foot and charged the customer 65 cents a foot for the same lead pipe; thereupon the city commission ordered the department to lay the services all the way into the house and set the meter, but we have not obeyed that order yet. I would like to know if anyone here has had that experience and their relation to the plumber especially with reference to fixing leaks in pipes which were installed under the old arrangement, and whether they allow plumbers to shut off water and remove meters?

MR. J. F. CHRISTY: You are getting into a matter now that is a problem with all active operators, especially water companies, that is, the problem of rules and regulations governing plumbing or ordinances governing plumbing. It is a great problem. I think it is a mistake to permit the plumber at any time to have any part in the handling of your meters. The water department should handle that the same as the electric department does all of the electric meters. We make the tap to the main and go to 18 inches back of the curb. There we install our meter box and our meter. We make a nominal charge of $4.00, that is all.

I have prepared an ordinance, after gathering the different ordinances in the cities which I visit, and talking with the water department and the plumbers and the city officials, relative to their experience, taking a part possibly from many and applying it to our particular city, requiring along with that the inspection of all plumbing. With the very best of care and with the closest inspection you have many problems, as the gentleman has spoken of here.

We permit the plumber on all repairs. We are practically now about 65 per cent metered and I hope within the next 18 months that we will be 100 per cent metered. That is the only way to furnish water. There is no more reason for furnishing water at a flat rate than for buying your groceries at a flat rate and getting the key to the grocery store and going in night and day and getting what you want. We want to get away from that. But now, with the repairs and the matter of carrying the service line from the meter into the house, I had an experience a few weeks ago where a plumber made a contract on a two story house, a house with two baths, two toilets and a servant's toilet in one of the houses and in the upstairs there was also three lavatories and a bath and two toilets. In his contract he had agreed to put in a 1-inch service line. We had made a 4-inch tap for this property. The service was unsatisfactory in the very beginning, and they were unable to get enough water. Our pressure averages about 60 pounds; we operate from about 50 to 72 pounds, but our average pressure is about 60 pounds. They called our office and asked what might be the trouble, thinking possibly that our men had not turned on the water cock full when they placed the meter at the curb. The superintendent sent a man out and found that the water was all right. We went into the house and made the openings and found the water flowing, turned on the service below and above and found that the flow was really not what it should be. Then they asked to talk with me, and I asked them if they knew what went in. He said, "Our contract is for an inch line." I said "Do you know that you have got that." "No, I do not; I do not know what went in." I sent the foreman out and told him to make an inspection. He found a ½-inch line in there. Those are the problems. I feel that a water department is operating for the public benefit. The public is entitled to every courtesy that can be extended on the part of the water company, and where we can help them along these lines, we should do so; but when you come to handling the plumber, you have another job on your hands. If the difficulty is out of our jurisdiction, the only thing we can do is to advise and suggest, and then let them take it to the proper authorities, if they have a plumbing inspector. But oftentimes you have got to go after the plumbing inspector and when you do he will often say, "I have not made an inspection of that house." At all times I feel that the water company should do all they can to help the company get what he pays for.

A MEMBER: I think we are on the right track, but I realize that we are biting off a big contract to obey that order that has been issued to us. We have been ordered to draft an ordinance covering that, and we are marking time to get more information on it. I cannot understand what kind of an ordinance you have that requires you to carry that pipe in on to private property.

MR. J. F. CHRISTY: Have you consulted your attorney to know that when you write that ordinance there will be anything to it?

A MEMBER: Yes.

MR. J. F. CHRISTY: I do not believe they can draft an ordinance that will require you to run your line on private property. From my experience I do not believe it is constitutional, and I would not do it if there is any way out of it. When the water company goes on private ground, it is another proposition. I think the water company should go no further than the property line at any time. We go 18 inches back of the curb. I will not even put meters in the basements of residences. We are required to do that some times in factories or business houses, but I will not do that if there is any other place I can put them, even on our main street, where we put our meters right back of the curb and place our box absolutely level with the concrete wall as you see over the city here in many places.

MR. HARRY F. HUY: The matter of as to who should pay for service connections is open for considerable discussion. If the municipality does it, there is no question who pays for it ultimately; the consumer pays for it somehow or other, but I think the utility should put the service pipe from the main to the house. Generally speaking, meters are located inside the building, especially in climates not favorable for outside setting. The costs should be borne by the property owner. The work should be done by the utility, to see that it is of satisfactory quality. We do not do our work by that method, but we provide that the service pipe from the main to the house must be laid under the inspection of the water company when the water company makes the tap. The plumber is on the job when the water company makes the tap and the tapper does not leave until the plumber puts the service in the house and runs the water through the service so that it is clear and clean.

MR. J. F. CHRISTY: What do you do in the case of repairs, if there is a leak?

MR. HARRY F. HUY: We do not do the work; we have an inspector there who checks the work.

MR. J. F. CHRISTY: But you do not lay that pipe?

MR. HARRY F. HUY: We maintain inspection. I agree with you that the problem of dealing with the plumbers is a hard one; but before the plumber makes the tap, he makes application for a service connection to a house. He has a contract submitted to him which provides that he has read the regulations and agrees to abide by them. If he does not read them and does not do what they call for, we simply will not make the connection at the main. At first we had considerable trouble. The plumber went to the owner and said that we were unreasonable in our rules; the owner came back to the water company and in some cases the owner went so far as to go to the local authority. We explained that we were not doing that to make it a burden, but to produce good results for their house and it was a benefit to have that inspection and work comply with the permit. We satisfy ourselves before the connection is made to the main that he puts in the pipe required under the code.

MR. R. B. MORSE: I would like to find out whether the plumbers are allowed to turn on water at any time or whether that is absolutely restricted to the department.

MR. WM. LUSCOMBE: In Gary we tap the main and install the service pipe to the property line at our own expense. We use extra strong lead pipe for that and we require extra strong lead pipe for all our underground work. The meters are invariably placed in the basement. The service pipes are inspected before they are covered to see if they are free of leaks. In cases of repairs the plumber, a licensed plumber, is permitted to turn the water off at our taps near the property line and turn it on again. We seal all our meters. The meters are read monthly. The meter readers are cautioned when any seals are broken, promptly to report them. We then investigate to find out what plumber was called in in connection with the job and make complaint to him of the injustice of it. Occasionally we find

the setting of a meter reversed, but by following up, we keep those cases to a minimum. I believe it is the rule rather than the exception to permit licensed plumbers to turn the water on or off at the property line or curb for repairs, but, in so doing, report it to the utility company or municipality.

MR. PATRICK GEAR: My friend here says he does not think it is constitutional. Why worry; let the other fellow fight out that question if he wants to. We are ready to furnish you with water, if you comply with our rules, if not, we do no business with you.

At our office you sign an application for a new service which must be paid for before the water is turned on, as for renewing a service the bill is to be paid for within 30 days. We put in pipe from main to cellar and a valve tee and plug inside of wall. The plumber starts his work from the tee and is not allowed to remove the plug from same, for that plug is put in for our convenience.

Should anything happen to the service afterwards we do not have to unhitch that pipe. We simply take out the plug, and if there is water there we are through. Should there be a break between the main and cellar we shut off the water, dig down and repair same immediately, but water is not turned on again until the owner of property has signed the document agreeing to pay for the same. Make your rule, play no favorites, and there is not enough at stake for any one to contest whether it is constitutional or not. Any one that ever questions the right of our commissioners on these rules and regulations are always advised by their counsel to quit.

MR. J. F. CHRISTY: That is perfectly all right if you choose to do that. That is your rule and you have adopted that rule yourself. I am talking about a city endeavoring to force a water company to carry its line over the property line into private property. In some cases it might be well to do that, but I have in mind a city council endeavoring to force a water company to run its lines over private property or force it to go into that home and do the plumbing.

A MEMBER: Perhaps I'd better make myself clear. In this case the water company is municipally owned and had been ordered by its own city commission to do that.

MR. D. R. GWINN: If you have not got a rule, make one. Everybody in business has a right to make their rules for their business. They may tell you that you have no right to do it, but do it anyway.

A MEMBER: I would like to ask Mr. Gear how they can expect the owner to maintain the service that the city puts in, that is that portion between the curb and the building, from the main into the building? You put the line only to the curb.

MR. PATRICK GEAR: We put it all the way in.

A MEMBER: And the owner maintains it from the curb-line to the building?

MR. GEAR: From the main to the cellar.

MR. POWELL: I am in the south, where we are not troubled with cold weather as they are in northern climates. We have a plumbing inspector who inspects all plumbing, and when a person makes application for water, they sign a contract, and when a plumber makes application to do the plumbing, he signs that permit saying that he has read section so and so, and if he does not read it it is his own fault. We carry our service to the curb and install the meter box and the curb box and from there on it is the customer's. We do not go beyond the curb in any case, and we maintain everything from the meter connection on the property side back to the main. If anything happens to it, it is up to us, beyond that it is up to the customer. We absolutely do not allow anybody, except an employee of the department, either to turn the water off or on. In every case where it comes to our notice that anybody has turned the water either off or on, unless the conditions were very unusual, such as a bursting waterback or something of that kind, I have always made a case against them. I have whipped the plumbers into line, so that they know better than to fool with it. We send a policeman right after the man who turned that water on or off. If we find water turned on, perhaps in a house that has been vacant three or four months, if the water consumption has not been enough to cover the minimum, we charge them a minimum. If the meter shows more than the minimum, we charge them for what has been used, and do not turn it on until it has been paid for. Then we make them pay a dollar more.

MR. HARRY F. HUY: I do not see how you can prevent a consumer from turning off his service.

MR. POWELL: We require the customer to have his own cut-off and we have ours.

MR. HARRY F. HUY: Suppose a house sets back?

MR. POWELL: We put his own cut-off in the yard.

MR. HARRY H. HUY: We have had that question at issue in the courts, as we operate a private company. Our courts have ruled that the customer has a right to shut off the water in case of emergency or any reason whatever.

MR. J. F. CHRISTY: The Supreme Court has held that.

MR. HARRY F. HUY: Yes. Suppose a man wants to go away from his property and leave it.

MR. POWELL: He turns it off at his own cut-off.

MR. HARRY F. HUY: Normally the curb stop is the shut-off, so that he has a perfect right to go out and shut it off. He has no right to turn it on in the design to defraud. If he turns it on with no design to defraud, I do not think you can hold him.

MR. POWELL: Possibly our positions are different from yours. There are a great many houses where they cut the water off at night. Most of our houses are not built to stand zero weather, and cold weather may last ten or twelve hours. When they want to cut the water off themselves, they have always got their own cut-off.

MR. SMITH: This is the first time I have had the pleasure of attending a Water Works Association convention, but in Richmond there is also under my jurisdiction the inspection of electric wiring, and we require that all wires be grounded to the water pipe. We have recently had a man badly burned in disconnecting the meter placed at the curb, owing to a ground in the building when he was disconnecting the meter. The current passed through his body and gave

him a very severe shock. Since that accident we require our men to carry with them a wire shunt which must be connected to the pipe before the pipe is closed. The purpose of that shunt is that, in the event of grounding a house, the current passing through the pipe will pass through the wire instead of through the man's hand. I am taking this opportunity to recommend that practice, which is very simple in its accomplishment, to those workmen who are present where grounding within the building is done.

MR. E. E. NORMAN: In Kalamazoo the electrical inspector requires the wire men to place a permanent shunt around the meter.

MR. PATRICK GEAR: I remember a place where there was a thunderstorm going on and a lady wanted to put her head under the faucet to get a drink of water, and got a shock that knocked her to the floor. She started to sue. We did not know that an electric wire was hitched on. Whenever we find a wire attached, we pull it off. They have no right to put it there; no law gives them any right to do it. They have asked the permission from the cities and towns and no city will give them permission to do it. A water department that gives permission to electricians to ground their wires on the service pipe is laying itself open to a damage suit. If we find them there, we pull them off and say nothing about it.

BYPASSING LARGE METERS DURING EMERGENCY REPAIR

A MEMBER: How many water works departments permit a bypass around a large meter for meters furnishing water to places where it cannot be interrupted for the removal of the meter? That is, having a valve in that bypass sealed or shut. I would like to know whether that is done in other companies, and with what success?

MR. HARRY F. HUY: The practice of the company I represent is to put a meter on the bypass, a very small sized meter.

A MEMBER: Do you let them get water at a reduced quantity then, while you repair the main meter?

MR. HARRY F. HUY: Not a very much reduced quantity, probably a reduced pressure; the quantity must be up to the amount they require, but it might be at a reduced pressure.

MR. W. E. MILLER: In the Transactions of the Association, an article published before I joined the Association advocated not installing any larger than 2-inch meters. If the consumer wanted more than the 2-inch meter could supply, additional 2-inch meters should be placed in parallel. That obviates the difficulty of taking the large meter out and leaving the service unmetered for any length of time. I would like to know whether anyone knows if that practice is fairly general, and how satisfactory it is?

A MEMBER: Cedar Rapids, Iowa, has started to adopt that practice. We believe it would be better to install two meters. The accuracy of the registration will be better from two meters than from one. If one meter is out of service, if it should get out of order, the other will probably not get out of order.

A MEMBER: I would like to ask the gentleman how he thinks the accuracy of two 2-inch meters in parallel will compare with one 3-inch compound meter?

A MEMBER: The compound meter should be more accurate, according to the theory, but we have found that compound meters are not entirely satisfactory at all times.

A MEMBER: We use a compound meter at the present time and are considering the practice you just mentioned. That is why I brought up the question of by-pass.

George H. Benzenberg

May 31, 1925

George H. Benzenberg was born in New York City May 31, 1847, moving to Detroit with his parents one year later. He received his early education in Detroit and graduated as Bachelor of Science in Civil Engineering at the University of Michigan in June, 1867.

Following graduation, he was engaged for two years on primary triangulation of the Great Lakes. From 1870 to 1873, he served on the location and construction of the Milwaukee Northern Railroad from Cedarburg to Green Bay, Wisconsin. From 1874 to 1899 he served the City of Milwaukee as Assistant City Engineer, City Engineer and President of the Board of Public Works. He also served as Consulting Engineer and as a member of several engineering commissions for the following cities, in connection with their water works or sewerage systems; Cleveland, Kansas City, New Orleans, Omaha, Toledo, Racine, and a number of smaller cities. He completed the water filtration plant of Cincinnati, served as a trustee of the Northwestern Mutual Life Insurance Company from 1904 to his death. As Chairman of the Building Committee of the Trustees, he supervised the building of the home of this Company in Milwaukee, which is the outstanding building in the city and cost about three millions of dollars. In 1910 he retired from all professional activities, except that connected with the supervision of the construction of the above named building.

With the exception of the first six years, Mr. Benzenberg devoted his professional career to municipal work many monuments of which indicate his outstanding ability as a resourceful engineer.

While building the water intake tunnel under Lake Michigan, a distance of 6000 feet, for the City of Milwaukee, the contractors abandoned the work owing to the numerous blow outs. Mr. Benzenberg completed the work successfully by force account.

After the intake water tunnel, crib and shaft for the City of Cleveland had been abandoned, he took up the work and, under his immediate direction, recovered the tunnel, crib and shaft.

His plan for keeping the Milwaukee and Kinnickinnic Rivers free of sewage pollution by means of fresh lake water pumped into these rivers near the city limits, was a bold undertaking and was condemned by many prominent engineers as impracticable. He built the works and they have been eminently successful. To no other man is the City of Milwaukee so much indebted for its excellent water, sewer and street improvements, he having originally planned them all and no material changes in these plans have since been found necessary.

In 1911, the University of Wisconsin awarded him the degree of Doctor of Science. From 1895 to 1897 he served as Director of the American Society of Civil Engineers; he was Vice President 1901–1902, and its President in 1907. In 1893–1894 he was President of the American Water Works Association and in 1895 became the first President of the American Society of Municipal Improvements.

In addition to his very active professional work, he was quite as active in Masonic circles in which he was widely known throughout his state and nation. He was a member of all the Masonic organizations and had served in official capacities in many. He received his thirty-third degree in 1886 and, at the time of his death, was one of the three active members of the Supreme Council from Wisconsin.

On December 16, 1879, Mr. Benzenberg married Miss Allie Wolfrum, who survives him; his daughter, Mrs. May Benzenberg Mayer, of New York City, also survives him.

Throughout his life, Mr. Benzenberg was one of those engineers having broadness of vision, bold initiative and high ideals and commanded the respect and confidence of the community in which he took such an active part to improve, and of those with whom he came into contact

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Pipe Line Freezing During Thaws. J. A. CRAWFORD and H. P. BLAKE. Railway Engr. and Maintenance, **21**: 112–3 (1925). Notes to the effect that instances have occurred where water has frozen in pipe lines buried as deep as 8 feet. It is recommended that water be kept moving to prevent trouble.—*R. C. Bardwell.*

Air Lift Pumping in Winter. P. M. LABACH and JOHN OLIPHANT. Railway Engr. and Maintenance, **21**: 69–72 (1925). Notes to the effect that trouble can be avoided with properly installed plant by protecting surface piping and connections.—*R. C. Bardwell.*

Water Tank Rebuilt Quickly. ANON. Railway Engr. and Maintenance, **21**: 72–2 (1925). A 100,000 gallon creosoted wood tank was built by Illinois Central Railway forces at Lamberth, Miss., between December 27 and January 5, or 7 actual working days.—*R. C. Bardwell.*

The Use of Lead as Compared with Substitutes for Joints in Cast Iron Pipe. Com. Rep., Amer. Ry. Engr. Assn., Bul. 272, 397–26 (1924). Use of lead, cement, composition, wood, and lead wool joints is described and notations as to where most adaptable.—*R. C. Bardwell.*

Hydraulic Rams for Use in Railway Water Service. Com. Rep. Amer. Ry. Engr. Assn., Bul. 272, 401–26 (1924). History, description, and charts are published, showing delivery to be expected and recommended length of drive pipe where quantity of water available and pumping head is known. Check of large installations in service indicates that the hydraulic ram makes an economical installation for Railway water supply where local and individual conditions will permit workable application.—*R. C. Bardwell.*

The Relative Economy of Different Methods of Pumping Water, considering the use of steam, electricity and oil pumping outfits and the purchase of water as compared to pumping. Com. Rep. American Railway Engineering Association, Bul. 272, 408–26 (1924). Where water of suitable quality and sufficient quantity can be purchased at reasonable cost, it is recommended above other sources. The cost of steam pumping stations varied from 2.0 to 8.8 cents per 1000 gallons and from 4.4 to 21.4 cents per water HPH. Electrically operated

stations reported vary from 0.75 to 3.6 cents per 1000 gallons and from 2.5 to 13.5 cents per WHPH. This reduction is due largely to reduction in labor expense. The costs reported on oil engine operation vary from 0.42 to 1.1 cents per 1000 gallons and from 0.74 to 3.3 cents per WHPH. Report concluded that fuel oil is cheapest power method for pumping water, electricity with automatic control next, and steam or electricity with attendants the most expensive.—*R. C. Bardwell.*

Pump Installation for Service and Standby Water Service. Eng. News-Rec., **94:** 670, April 16, 1925. Brief description of pumping equipment, motor driven with gasoline engine driven standby, installed at West Chicago, Ill., by American Well Works, Aurora, Ill.—*R. E. Thompson.*

Double-Suction Pump Designed to Neutralize End Thrust. Eng. News-Rec., **94:** 670, April 16, 1925. Means of automatically neutralizing end thrust in double-suction centrifugal pumps, developed by Earle Gear and Machine Co., Phila., described and illustrated.—*R. E. Thompson.*

Building Wilson Dam at Muscle Shoals on the Tennessee. Eng. News-Rec., **94:** 676–83, April 23, 1925, and 724–9, April 30, 1925. Detailed illustrated description of Wilson Dam, which, in volume, is largest concrete dam in world. Cost will be in excess of $50,000,000.—*R. E. Thompson.*

Safe Water Signs on Highways at Entrance to Minnesota Municipalities. Eng. News-Rec., **94:** 685, April 23, 1925. Signs indicating approved water supplies to be posted by Minnesota State Bd. of Health are described, and conditions of such approval summarized.—*R. E. Thompson.*

Better Prospects for Settlement of Owens Valley Dispute. Eng. News-Rec., **94:** 767–8, May 7, 1925. History of dispute between water users in Owens Valley and city of Los Angeles over city's policy in diversions from Owens River and in acquiring more land in valley is reviewed briefly and it is stated that there is now believed to be good prospect for final settlement of differences.—*R. E. Thompson.*

Low-Head Power Plant Designed for Typical Mid-West River. E. L. Chandler. Eng. News-Rec., **94:** 762–3, May 7, 1925. Pinhook Dam (earth and concrete) and spillway on Maquoketa River, Ia., described and illustrated. —*R. E. Thompson.*

Variations in Physical Values of Public Utilities. C. F. Lambert. Eng. News-Rec., **94:** 768–70, May 7, 1925. Relative yearly (1913–1924) variations in total physical costs, together with figures for each year of average value for 5 and 10 years preceding—all years before 1913 being taken as 100 per cent of 1913 values—are shown graphically for 5 types of public utilities including water works, and data tabulated showing yearly relative percentages of land, buildings, equipment, and miscellaneous making total cost, taking into account year-to-year variations.—*R. E. Thompson.*

River Diversions and Flood Control Projects in North Dakota. Eng. News-Rec., **94**: 774, May 7, 1925. Projects under consideration are reviewed briefly, diversion of Missouri River to assure ample supply of good water in eastern North and South Dakota being the most ambitious proposition. Restoration of Devils Lake, the only large body of water in North Dakota, is also under consideration.—*R. E. Thompson.*

Undermining Causes Failure of French Landing Dam. Eng. News-Rec., **94**: 735–6, April 30, 1925. Failure of French Landing Dam of Detroit Edison Co., on Huron River, on April 13, described and illustrated.—*R. E. Thompson.*

Moving Wood-Stave Tanks on Scow. G. C. GRUBB. Eng. News-Rec., **94**: 740–1, April 30, 1925. Brief description of method of moving 1000 and 2000-barrel wood-stave tanks by water to new location 50 miles distant.—*R. E. Thompson.*

Fuel and Road Oil Applied as Binder on Earth-Fill Dams. Eng. News-Rec., **94**: 737, April 30, 1925. Brief illustrated description, with cost data, of oiling of Encino and San Fernando Dams of Los Angeles aqueduct system to prevent damage from wave action.—*R. E. Thompson.*

Jamestown, N. Y. Eng. News-Rec., **94**: 801, May 14, 1925. Water supply of Jamestown is derived from artesian and other wells and requires no treatment.—*R. E. Thompson.*

New Gravity Supply for Staunton, Va. LEE H. WILLIAMSON. Eng. News-Rec., **94**: 803, May 14, 1925. Present supply which is derived from limestone springs, is inadequate and unsatisfactory owing to hardness. New supply will be drawn from 150-m.g. impounding reservoir formed by dam on north fork of Shenandoah or North River. The drainage area of 25 square miles is situated in the National Forest Reserve and is therefore free of pollution.—*R. E. Thompson.*

Proposed Experimental Arch Dam on Stevenson Creek. Eng. News-Rec., **94**: 816–7, May 14, 1925. Design sketches and discussion of experimental arch dam to be built on Stevenson Creek in southern California by Committee on Arch Dam Investigation of Engineering Foundation.—*R. E. Thompson.*

Sinking, Cleaning and Testing Wells on the Los Angeles Aqueduct. GEO. R. SHUEY. Eng. News-Rec., **94**: 820–2, May 14, 1925. Auxiliary supply is being developed during present dry cycle by drilling wells into gravel beds in lower part of Owens Valley, 75 wells having been drilled to February 10, the total production of which is 90 second feet, nearly one-fourth of carrying capacity of the aqueduct. Method of sinking, cleaning and testing described briefly.—*R. E. Thompson.*

Pipe Backsite 120 Feet High Set at Dam Curve Centre. Eng. News-Rec., **94**: 822, May 14, 1925. Brief illustrated description of backsite employed during construction of Exchequer Dam.

Protecting Steep Banks by Planting Live Willow Poles. Eng. News-Rec., **94**: 822–3, May 14, 1925. Patented method of bank protection, known as angular submerged tree planting, described, and successful applications illustrated. The method consists of grading to uniform slope and burying live white willow trees, salix alba, in shallow trenches with butts at toe of slope in moisture. The poles take root and send up sturdy shoots for their entire length.—*R. E. Thompson.*

Tractor Delivers Pipe Sections from Train to Trench. Eng. News-Rec., **94**: 824, May 14, 1925. Brief description of method of handling pipe sections in construction of pipeline to convey first Calaveras and later Hetch Hetchy water into San Francisco-Peninsula reservoirs.—*R. E. Thompson.*

Bully Creek Dam Failure Due to Unsupported Core-Walls. Eng. News-Rec., **94**: 870, May 21, 1925. Brief description and discussion.—*R. E. Thompson.*

Vertical Check Valves Used as Air Valves in Supply Mains. EUGENE CARROLL. Eng. News-Rec., **94**: 859–60, May 21, 1925. Vertical check valves have given good service as air valves on 73 miles of gravity and pumping mains of Butte Water Co., Butte, Montana. Difficulty of freezing of water in check valves has been eliminated by means of special outside air connection designed for this purpose.—*R. E. Thompson.*

Hydrant Spacings, Water Pressures and Size of Fire Hose. WM. R. CONRAD. Cont. Rec., **38**: 996–8, 1924. Except in localities containing high buildings covering considerable ground areas the water supply system should be capable of providing ample water for sufficient number of hose streams at 90 pounds pressure, with hydrants not more than 200 feet apart. Data on delivery of water through 1½, 2½, and 3-inch hose and combinations of 3 and 1½, and 3 and 2½ are given, together with quotations supporting author's favorable conclusions regarding value of 3-inch hose.—*R. E. Thompson.*

Simplifying Meter Reading and Billing. STEPHEN B. STORY. Cont. Rec., **38**: 1026–7, 1924. A system of continuous meter reading and billing has been developed by Rochester Bureau of Water to eliminate rush of work which formerly occurred at end of each quarter. On first day of each month one-third of consumers' accounts fall due, the work being thus distributed and the staff provided with steady employment. Established daily quota for meters read and for bills distributed is 95 and 300 respectively.—*R. E. Thompson.*

Some Tests to Determine Resistance Against Leakage of Riveted Plates Supported on Beams or Columns. GEO. T. HORTON. Cont. Rec., **39**: 152–5, Feb. 18, 1925. Following conclusions drawn from tests of flat-bottomed water tank: (1) Thin flat bottoms are in tension and act similarly to buckle plates. (2) Slight moisture at seams will accompany deflection of 1/40 of span, occasional dripping with deflection of 1/30, and considerable leakage with 1/20. (3) Weak point for both stress and leakage is over support. (4) Bottom plates

fail in tension over supports rather than shear at edge of supports. (5) A $\frac{3}{16}$-inch flat-bottomed tank can be supported on 4-inch square columns at 7-feet centers with lead of 3-feet of water and have factor of 4 in regard to stress and show no leakage.—*R. E. Thompson.*

Underfeed Stokers Burn Low Grade of Coal. C. E. Reese. Blast Furnace Steel Plant, **10**: 588–91, 1922. From Chem. Abst., **17**: 1126, March 20, 1923. Details given of specially designed underfeed stokers for burning low-grade coal at boiler plant of Twin City Rapid Transit Co., Minneapolis, Minn. Average operating efficiency is approximately 70 per cent at 350 per cent of rating.—*R. E. Thompson.*

Iron Bacteria and Their Relation to Algae. N. Cholodny. Ber. botan. Ges., **40**: 326–46, 1922. From Chem. Abst., **17**: 1490, April 20, 1923. Small lumps of jelly-like substance incrusted with ferric hydroxide and found on filaments of algae, particularly on Conferva, are described. These lumps are produced by a species of bacteria, viz., Sideromonas confervarum. Possibility of symbiosis between the algae and the bacteria is discussed.—*R. E. Thompson.*

Our Broadening Knowledge of Lubrication. A. E. Dunston and F. B. Thole. Chem. and Met. Eng., **28**: 299–302, 1923. From Chem. Abst., **17**: 1289, April 10, 1923. Review with suggested research program.—*R. E. Thompson.*

Note on Stabilized Bleaching Powder for Tropical Use. F. S. Aumonier and S. Elliott. J. Royal Army Med. Corps, **39**: 459–60, 1922. From Chem. Abst., **17**: 1308, April 10, 1923. Bleacb stablilized with 30 per cent lime stands storage on laboratory scale in tropical climates and does not deteriorate to any appreciable extent for few days after opening. Stoneware jars showed no advantage over sealed tins. On large scale mixture tended to "fire" and lose chlorine, but this difficulty was minimized by control of temperature.—*R. E. Thompson.*

Effect of Chemical Solutions on Various Woods Used in Tanks. S. J. Hauser and Clarence Bahlam. Chem. Met. Eng., **28**: 159–63, 1923. From Chem. Abst., **17**: 1314, April 10, 1923. Relative amounts of color and taste imparted to water by test strips of air-seasoned red gulf cypress, Douglas fir, long-leaf yellow pine, California redwood, hard maple, and white oak were recorded. Cypress imparts neither appreciable color nor taste to water; redwood and oak yield colored aqueous solutions; and fir and pine give solutions with pronounced tastes. Of the various liquids examined with regard to their action on the woods, bleach solutions were among the most highly corrosive.—*R. E. Thompson.*

Damage from Oxygen in Boiler Feed Water. G. H. Gibson Elec. World **81**: 167, 1923. From Chem. Abst., **17**: 965, March 20, 1923. Corroding of

iron in economizers and boilers is directly proportional to concentration of oxygen in feed water. Deaeration must be secured in some manner, such as by maintaining partial vacuum, if the water is not kept at boiling point.—*R. E. Thompson.*

The Oxygen Content of Waters in the Strait of Georgia. C. J. BERKELEY. Contrib. to Can. Biology, 1922, 71–2. From Chem. Absts., **17**: 1031, March 20, 1923. By Winkler's method fairly concordant results were obtained, values of about 6 cc. per liter for surface waters steadily diminishing to 3.5 at 20 fathoms, and less than 2 at 200 fathoms. The method, used with sea water, involves an uncertain error of about 3 per cent, which can be paralleled by addition of magnesium salts to tap water, with which, alone, perfectly concordant results were obtained.—*R. E. Thompson*

Tools of the Chemical Engineers. I. Agitators. D. H. KILLEFFER. Ind. Eng. Chem., **15**, 144–8, 1923. From Chem. Abst., **17**: 903, March 20, 1923. Agitators are classified as (1) paddles, (2) turbines, (3) propellers, (4) moving vessels, (5) combinations of above, (6) miscellaneous. Article is descriptive only.—*R. E. Thompson.*

Ozone and Tautomerism. P. DE PAUW. Chem. Weekblad, **20**: 26, 1923. From Chem. Abst., **17**: 939, March 20, 1923. Ozone should be defined as dynamic isomeric form of oxygen, not as allotropic form.—*R. E. Thompson.*

Preservation of Standard Solutions of Oxalic Acid, and the Reading of Burets. SABURO ISHIMARU. J. Chem. Soc. Japan, **43**: 767–72, 1922. From Chem. Abst., **17**: 940, March 20, 1923. Experiments with pure oxalic acid solutions and with oxalic acid solution containing sulphuric acid indicate that addition of acid as preservative is unnecessary, but that the solution should be protected from light. Device is described for avoiding parallax errors in buret reading.—*R. E. Thompson.*

Accurate Proportioning Device for Water Treatment Chemicals. Eng. News.-Rec., **94**: 669, 1925. The so-called International Head Chamber for proportioning chemicals for water treatment is described briefly and illustrated.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Drain Valve for Chemical Solution Tanks at Filter Plant. C. L. B. ANDERSON. Eng. News-Rec., **94**: 661, 1925. For use in soda solution tanks, and, to lesser degree, in lime solution tanks, iron mounted angle valves have been found most satisfactory. With Al_2SO_4 and hypochlorite solutions best service has been obtained with valves having seats and working parts of bronze or monel metal, phosphor bronze being most satisfactory and tobin bronze and monel metal giving approximately 20 per cent less service. New type of valve designed by author, consisting of soft rubber stopper with necessary actuating mechanism, is described.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Small-Capacity Chlorinator Has Thermostatic Control. Eng. News-Rec., **94**: 670, 1925. Simplified "Paradon" chlorinator consisting of pedestal having water-jacketed compartment for holding small cylinder of Cl (12 pounds), Ag control valve, volumetric type measuring meter, and injector, described briefly and illustrated. Advantages claimed are resistance to corrosion even by moist Cl, elimination of necessity of compensating reducing valve by temperature control, and compactness.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Ohio Stream Pollution Law Amended to Give Increased Control. Eng. News-Rec., **94**: 696, 1925. New legislation recently enacted, materially increasing power of Ohio State Department of Health to control stream pollution, is given in full and briefly discussed. The Department is authorized to supervise plants for treatment of sewage and industrial wastes and to investigate water pollution generally throughout the state.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

New Gravity Water Supply in Use at Charlottesville, Va. LEE H. WILLIAMSON. Eng. News-Rec., **94**: 689, 1925. New water works at Charlottesville consists of intake dam on Moormans River, grit chamber for removal of heavier flood-flow turbidity, and 2.5 m.g.d. slow sand filtration plant operated at 5 m.g.d. rate. Slow sand filters were adopted as turbidity is low and color seldom exceeds 25. Initial cost was higher than for mechanical filters, but operating costs considerably less. To date plant has given very satisfactory results, effecting an unusual color reduction and averaging 13 weeks between scrapings.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Typhoid Fever and Cross-Connections in Illinois. Eng. News-Rec., **94**: 526–7, 1925. Occurrence of 12 cases of typhoid and paratyphoid in Sterling and Rock Falls, Ill., was traced to cross-connection between private and city supply which had been permitted notwithstanding warning of the State Board of Health.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

City of Santa Cruz Extends Water System. Eng. News-Rec., **94**: 603, April 9, 1925. Following hasty installation of pressure filters and chlorination plant during low-water period last fall, 37-m.g. concrete-lined reservoir and 6-mile pipeline for conveying water from Major's Creek have been constructed. Old supply, derived from springs and small streams, with new source and filter plant as standby, is expected to be adequate for some years. —*R. E. Thompson.* (*Courtesy Chem. Abst.*)

New Type of Chlorinating Apparatus at Albany Water Works. THEODORE HORTON. Eng. News-Rec., **94**: 650–1, 1925. New apparatus (U. S. Pat. 1,423,217, July 18, 1922) is described consisting essentially of control valve, pressure gage, manometer, and rate-of-flow chart. Need of compensating valve is entirely eliminated and check valve is considered unnecessary. Principle on which instrument operates in coördination between loss of pressure from flow through short tube and density of gas. Two of these chlori-

nators have been in use in Albany for some months.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Water Works Problems in a Town of 1,000 People. HARRY P. LETTON. Eng. News-Rec., **94**: 652–3, 1925. Difficulties experienced at Weeping Water, Neb., plant, due to unintelligent supervision and operation, described. Copper sulfate treatment was found inadequate for removal of taste and odors due to green growths. Simple aërator, consisting of open-work tower surrounding spray nozzles, was constructed and has proved most successful.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Progress on Border Cities Filtration Plant. Cont. Rec., **38**: 975, 1924. Water drawn from upper Detroit River, through 48-inch intake of 60,000,000 gallons capacity, will be treated at plant consisting of 10 rapid sand filters of 2 million gallons capacity each, estimated cost of scheme being $800,000. System will supply 8 municipalities with combined population of approximately 80,000. [See following abstract.]—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Novelties in the New Water Filters at Windsor, Ont. Eng. News-Rec., **94**: 655, 1925. Unique features of plant are operating tables controlling 2 filters independently with same levers, and cemented-gravel layer over perforated-pipe underdrains in the filters to prevent intermixture of gravel and sand. [Cf. preceding abstract.]—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Rehabilitation of Small 30-Year-Old Water Works Plant. F. M. VEATCH. Eng. News-Rec., **94**: 658–9, 1925. Recent improvements to Kirksville, Mo., plant include new intake pipeline to River Chariton, 1.25-m.g.d. rapid sand filter plant, new pumping equipment, and extensions to distribution system. —*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Copper Sulfate Sown on Ice of Cheyenne Water Works Reservoirs. P. R. REVIS. Eng. News-Rec., **94**: 660, 1925. Application of $CuSO_4$ by means of bags drawn through water by boats was found to be slow, expensive, and uncertain; this year the chemical was scattered over ice covering reservoirs in mid-winter at rate slightly in excess of 30 pounds per acre, equivalent to 3 pounds per million gallons. Nearly 5 tons of $CuSO_4$ were distributed over 312 acres by 4 men in 5 days. Taking advantage of wind, each man covered strip 150 feet wide at single passage across ice.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Filtration Plants for Chicago Water Proposed. Eng. News-Rec., **94**: 782, 1925. Brief discussion of proposed installation of 5 filtration plants for treatment of Chicago's water supply.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Pneumatic Handling of Granulated Chemicals. ARTHUR F. MELLEN. Eng. News-Rec., **94**: 857–8, May 21, 1925. Possibilities of handling granu-

lated alum pneumatically have been studied at Columbia Heights filtration plant, Minneapolis, Minn., and this method has been considered in design of Fridley filtration plant now under construction.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Goiter and Drinking Water. J. A. GOODFELLOW. Munic. Eng., **75**: 526–7, 1925. General discussion of iodine deficiency theory of goiter and of iodization of water. Water supplies of Ilkeston and Heanor are being treated with sodium iodide as at Rochester, N. Y., except that salt is applied continuously. At Ilkeston, where consumption averages 1,600,000 gallons per day, 2 pounds of sodium iodide were added per week.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Oxyacetylene Cut Does Not Injure Ductility of Steel. Eng. News-Rec., **94**: 939, 1925. Tests at laboratories of Union Carbide and Carbon Co., N. Y. City, showed that flame cutting does not injure the metal, both strength and ductility of flame-cut surfaces being equal to those of milled or hacksawed surfaces. A slight hardening effect of flame was indicated in strength figures but milling off of $\frac{1}{8}$ inch from flame-cut surface removed hardened metal. The tests indicated that shearing produces marked reduction in ductility.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Lynchburg, Va. Eng. News-Rec., **94**: 978, 1925. Water supply is conveyed through 21 miles of wood-stave pipe from Pedlar River in Blue Ridge Mountains, and treated at filter plant consisting of 12 units.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

More Tub Filters Being Built at York, Pa. Eng. News-Rec., **94**: 777, 1925. Six 0.5-m.g.d. rapid sand filters of tub type are being added to installation constructed at York, Pa., in 1899 and added to in 1908 and 1920, completing program adopted 25 years ago. When capacity of plant is reached it is proposed to install high-velocity-wash rapid sand plant which will be extended gradually to assume load from tub filters as they reach end of period of usefulness. It is estimated that, with reasonable expenditure for overhauling, old filters, which yield water of satisfactory quality at moderate operating costs, will give satisfaction for further 10 years.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Reinforcing the Water Supply of Horton, Kans. N. T. VEATCH. Eng. News-Rec., **94**: 931–2, 1925. Recent improvements to Horton water supply system include earth-fill dam on Mission Creek, intake, and pipeline to existing purification plant consisting of coagulation basin and filters constructed in 1910. Ultra-violet ray treatment is employed for sterilization.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

To What Extent May Disinfection Take Place of Filtration? WALDO S. COULTER. Fire & Water Eng., **75**: 995, May 14, 1924. Disinfection alone may suffice for clear waters lightly polluted. Filters for the removal of tur-

bidity from such waters may be safely designed for clarification mainly, dependence being placed on disinfection to effect the limited bacterial removal required. The principal difficulty presented by such treatment is that, once established, it may be continued unchanged after the raw water has become quite heavily polluted. Where pollution is important, even if only occasionally, effective filtration as main line of defense should not be dispensed with, whilst disinfection of filtrate should form regular, though supplementary, part of treatment. So long as B. coli in raw water does not exceed about 50 in 100 cc. (annual average), or is absent in more than 50 per cent of 1 cc. samples, reliance may be placed chiefly on disinfection. Author is averse to this practice, however, because, once established, it is apt to be adhered to in face of increasing pollution, until matters become intolerable.—*Geo. C. Bunker.*

The New $3,000,000 Water Supply Project at Waterbury, Conn. THOMAS F. MAGNER. Fire & Water Eng., **75**: 997, May 14, 1924. City is constructing 7 mile tunnel in order to bring water from reservoir to be built on Shepaug River at location about 1 mile beyond Woodville. About 6 miles remain to be drilled; to April 24 cost was $682,676. No details included as to dam across Shepaug River and capacity of reservoir.—*Geo. C. Bunker.*

Methods That Keep Our Water Works up to Snuff. GEORGE W. BATCHELDER. Fire & Water Eng., **75**: 999, May 14, 1924. Development of water supply of Worcester, Mass., has been gradual, system consisting of 9 impounding reservoirs storing run off from comparatively small water sheds on hills lying westerly from city. Present storage capacity is 3.3 billion gallons to which will be added 3 billion gallons more when Pine Hill reservoir is completed and filled in 1925. Five reservoirs, with combined storage of 2.5 billion gallons, furnish water to high pressure system by gravity, under pressure of 145 pounds at city hall, through 3 cast iron pipe lines 20-, 24-, and 36-inch, respectively. Three reservoirs, with combined storage of 1.8 billion gallons, to which new reservoir will be added in 1925, furnish water to low pressure system by gravity, through 2 cast iron mains, 30- and 48-inch, as does 40-inch line running from equalizing reservoir which gets its supply from high service reservoirs. Hydrants are installed and maintained by water department without expense to city. During winter months every hydrant in business district is inspected every 2 days and in residential district every 4 days. Emergency squad and automobile are always ready for service. Besides tools they are equipped with card index arranged in sections so that in case of broken main it is only necessary to take sectional card from box and on it is shown location of each gate necessary to close to stop leak. Department is governed by water committee of city council; present water commissioner acts as superintendent and registrar.—*Geo. C. Bunker.*

In This Gas Pump Water Acts As A Piston. F. JOHNSTONE-TAYLOR. Fire and Water Eng., **75**: 1001, May 14, 1924. In Humphrey gas pump, gas or oil fuel is exploded in combustion chamber, acting directly on the water

and lifting it in one operation; expansion is carried down to atmospheric pressure, no energy being lost in exhaust. It is well suited for raising large volumes of water through low lifts, practical range of working lift being from 8 to 150 feet. The fuel consumption is remarkably low, about 1 pound of anthracite being used per pump horse power per hour. At Chingford reservoirs of Metropolitan Water Board of London, are 5 pumps with total capacity of 180 million gallons per day, maximum lift being 30 feet. Gas is supplied by pressure producer of Dowson pattern, governor gear being fitted to keep gas production equal to consumption. Diameter of each pump is 7 feet and maximum H.P., 300. Illustrated.—*Geo. C. Bunker.*

The Proper Way To Paint Fire Hydrants. GEORGE PRICE. Fire & Water Eng., **75:** 1003, May 14, 1924. Yellow possesses sufficiently high visibility by natural light and almost maximum visibility when artificial light at minimum; it does not soil or mar as readily as some lighter shades. Cadmium yellow (sulphide of cadmium) is rather expensive, but is most permanent of the yellows. Chrome yellow (chromate of lead) of a light shade costs about half as much but will not retain clear tone and bright finish so long as cadmium.—*Geo. C. Bunker.*

Water Supply Problems of the Far East. Fire & Water Eng., **75:** 1064, May 14, 1924. From Far Eastern Review. Hongkong, in order to expand, must derive its future supply from mountains in leased territory across the bay in Kowloon. This means laying water mains under harbor, and divers now investigating with view to drawing up plans accordingly. New Singapore scheme has been investigated and reported on by Binnie, Son, and Deacon and published by municipal council. Scheme ultimately recommended consists in impounding various streams tributary to Pulai River. Development of scheme involves 6 installments, yielding 6.5 million gallons; 4 yielding 3 million gallons; and final one of 1.5 million gallons. First installment is estimated to cost $12,103,000, subsequent ones each about 2½ millions; total $22,258,000. All later installments involve construction of pumping stations and second gravity main with capacity of 8 million gallons per day, first main having carrying capacity of 12 million gallons per day. First 6.5 million gallons will flow by gravity to Pearl's Hill through pipe line 31 miles long. In Manila, during rainy season present water supply system is quite adequate, rainfall being heavy enough to meet all possible current demands. But Montalban reservoir is not large enough to take care of city demand during emergencies such as periodically occur during dry period, and on more than one occasion in past has water supply come perilously near to exhaustion. With consumption constantly on upgrade, really serious shortage is not beyond realm of possibility, nor even of probability. Of various projects for increasing supply which have been suggested, that which meets with most favor among experts is Angat River project. As this will take several years to complete, immediate action toward its construction is urged by business organizations. In Osaka another large water works undertaking has been investigated and reported on by local water bureau. This contemplates use of waters of Lake Biwa after their discharge from great

hydro-electric plants on Uji River to supply cities of Osaka, Kobe, and Sakai with their neighboring towns and villages.—*Geo. C. Bunker.*

Field Current Adjustment of Synchronous Meters. Q. GRAHAM. Power, **61**: 6, 209. February 10, 1925. Discusses effects on performance of synchronous motors of variations in field current. By means of curves it is shown that with constant field current, leading reactive kva. increases while total kva. decreases as lead is reduced on synchronous meter. Other curves show how armature current varies with change in field current; relation between power factor and efficiency; and variation in pull-out torque with change in excitation.—*Aug. G. Nolte.*

Solid-Injection Engine with Novel Features. Power, **61**: 6, 212, February 10, 1925. New Fees four-stroke-cycle oil engine is illustrated and described. —*Aug. G. Nolte.*

A Modern Tropical Central Station. P. A. PACKARD. Power, **61**: 6, 220, February 10, 1925. Improvements made in power plant of Calcutta Electric Supply Company are discussed.—*Aug. G. Nolte.*

Pulverized Coal at Cahokia. E. H. TENNEY. Power, **61**: 6, 222, February 10, 1925. Coal used at Cahokia contains high percentage of ash, frequently in excess of 16 per cent. Quality of this ash is largely accountable for erosion of sidewalls. Ash contains 18.5 per cent of iron with fusing temperature of 2000 degrees F. Coal contains 5 per cent sulphur. Ash becomes flux for firebrick. Experiments being made to improve quality of brick. Various other changes are being made to improve conditions.—*Aug. G. Nolte.*

Water-Cooled Furnaces. H. D. SAVAGE. Power, **61**: 6, 234, February 10, 1925. Abstract of paper read before Chicago Section of American Society of Mechanical Engineers, January 14, 1925. Water cooled walls favored over hollow wall construction for stoker furnaces and with pulverized fuel and preheated air considered essential. Fin-type furnace is discussed.—*Aug. G. Nolte.*

Some Preliminary Observations from a Study of Water Filtration Plants Along the Ohio River. H. W. STREETER. Public Health Reports, **40**: 5, 202, January 30, 1925. Survey was made of actual performance of ten municipal filter plants of rapid sand type located directly on Ohio River and taking their raw water supplies from that stream. Plants divided into two subgroups according to extent of treatment given water prior to filtration; Group 1 employing sedimentation in two separate stages and Group 2 employing coagulation followed by single stage of sedimentation. Data collected from each plant have comprised daily laboratory and operation records. Items such as raw water conditions, purification efficiencies, bacterial quality of effluents and relation of bacterial character of effluents to that of influents are discussed. In brief, following definite conclusions are drawn from data thus far analyzed: (1) With continuous use of chlorine disinfection of filtered

water, plants as group are able to deliver safe water for very long proportion of the time; without chlorination, they would undoubtedly be unable to do so. (2) Type of plant represented by Group 1 is more efficient in bacteria removal than type represented by Group 2. (3) Existance of well defined relation between bacterial content of effluents and that of influents of water purification processes has been confirmed.—*Aug. G. Nolte.*

Long Beach Steam Station of the Southern California Edison Co. F. S. CLARK and M. W. CARTY. Power, **61**: 7, 246. February 17, 1925. General description of plant and its auxiliaries.—*Aug. G. Nolte.*

Operation of Diesel Engines. R. HILDEBRAND. Power, **61**: 7, 255, February 17, 1925. Lubricating oil and its application are discussed. Usually, three different kinds of lubricant are used: one for power cylinder; one for crank case system, lubricating and crank shaft bearings, crankpins and wristpins; one for compressor. For power cylinders and crankcase pure uncompounded mineral oils, neutral filtered as final process of manufacture, should be used. Lubricants for compressor, are either pure mineral oils or mineral oils compounded with vegetable oils. Idea that inferior oil copiously applied to cylinders will do as well as good oil is erroneous. Gumming up of piston rings results from use of too much oil. Oil feeds to each cylinder should be regulated and adjusted independently. Dirt and grit should be kept out of oil. All joints should be kept tight to prevent fuel oil mixing with lubricant. Water entering crankcase will form an emulsion with oil. Carbon entering crankcase accentuates tendency of oil to form sludge or muck with emulsified water. Sludge formation seems to depend a great deal on acid content of oil. As sludge formation can hardly be prevented, suitable strainers or filters for oiling systems, to keep lubricating oil in good condition, should be provided. An oiling and a purifying system are illustrated.—*Aug. G. Nolte.*

Uniflow vs. Compound Duoflow Engines. R. CRAMER. Power, **61**: 7, 263, February 17, 1925. Abstract of paper read before Chicago Section of American Society of Mechanical Engineers, January 14, 1925. Different characteristics of these engines are discussed.—*Aug. G. Nolte.*

Large Curtis Turbines. O. F. JUNGGREN. Power, **61**: 8, 290, February 24, 1925. Discussion of F. HODKINSON's paper, "Steam Turbine and Condensing Equipment," presented at World's Power Conference, July, 1924.—*Aug. G. Nolte.*

New Fairbanks-Morse Diesel Oil Engine. Power, **61**: 8, 296, February 24, 1925. Operates as full Diesel without use of auxiliary ignition. Compression is 500 pounds. Is of two-stroke-cycle, solid injection type, with crankcase compression for scavenging. Fuel pumps are grouped on a pump deck and inclosed in case serving as fuel-oil reservoir. Compact inclosed unit at one end of main shaft contains injection system and mechanism for governing, air starting, and fuel control.—*Aug. G. Nolte.*

Testing Alternating-Current Motors. J. E. HEUSLEY. Power, **61**: 8, 301, February 24, 1925. Various conditions to be examined are enumerated. Selection of instruments required for tests is discussed and list of meters for proper motor testing is suggested. Proper compilation of test data is essential. In making tests, following data should be obtained:—temperature, speed, amperes, voltage, kilowatts. Diagram of meter connections for testing alternating-current motors is given. Tests may be arranged so as not to interfere with production processes.—*Aug. G. Nolte.*

Effect of Indicator Motion on Oil Engine Diagrams. R. C. SHOOK. Power, **61**: 8, 306, February 24, 1925.—*Aug. G. Nolte.*

Hydro-Electric Plant Has 452,500 Horsepower Installed Nominal Capacity. Power, **61**: 9, 325, March 3, 1925. Some engineering features of recently completed 210,000 hp. extension to Hydraulic Plant No. 3 of Niagara Falls Power Company. Extension consists of concrete-lined horseshoe-shaped tunnel, 4300 feet long by 32 feet inside diameter, three concrete-lined penstocks 21 feet inside diameter, three butterfly valves 23 feet 6 inches inside diameter, three Johnson valves 24 feet 4½ inches outside diameter, and three 70,000 hp. vertical-shaft single-runner turbine units.—*Aug. G. Nolte.*

Operating Centrifugal Pumps in Combination. R. K. ANNIS. Power, **61**: 9, 331, March 3, 1925. Question of how to increase capacity of centrifugal pumping units is discussed in considerable detail. There are two general methods of connecting a new pump into line in order to increase capacity, one "series" and the other "parallel". Former is used to build up pressure; latter increases rate of flow. There is no general answer to question of increasing capacity of an outfit; sometimes series connection is better and sometimes parallel. Each case must be studied separately.—*Aug. G. Nolte.*

Arc Welding in Power Plants. W. L. WARNEP. Power, **61**: 9, 336, March 3, 1925. Examples and illustrations on applying electric-arc welding in steam, oil engine, and hydro-electric power plants; also on structural-steel frame work. Savings effected are often sufficient to pay good share of first cost of welding equipment necessary.—*Aug. G. Nolte.*

Operation of Diesel Engines. R. HILDEBRAND. Power, **61**: 9, 339, March 3, 1925. Oil purifying systems and their advantages. Every Diesel Engine Plant should be equipped with some effective apparatus for clarifiyng lubricating oil, either in shape of filter, centrifugal oil clarifier, oil reclaimer, or settling tanks. Principle of operation of each of above systems is described. —*Aug. G. Nolte.*

Some Recent Developments in Use of High Pressure and Superheated Steam. B. N. BROIDE. Power, **61**: 9, 352, March 3, 1925. Excerpts from paper presented at joint meeting of the Eng. Soc. of Western Pennsylvania and the Pittsburg Section of the A. S. M. E., October 6, 1924.—*Aug. G. Nolte.*

Plant Inspection and Maintenance Schedule. G. E. GASTER. Power, **61:** 10, 373, March 10, 1925. Many advantages to be obtained by efficient schedule. Discovered defect repaired will cost much less than expense after neglect has led to failure. Author gives carefully prepared table of inspection intervals for various units of steam division and building of large power plant. In determining length of time between inspection periods on different units, following factors were considered: (1) Safety; (2) Reliability of Service; (3) Inherent characteristics of unit in regard to ruggedness; (4) Demand for unit. In order to insure that all work will be done at proper time it will be found advisable to make out schedule covering every week of year. Printed report blanks for recording inspections and repairs made can be filed for future reference. [This system will be found very applicable and of inestimable value in maintenance of filtration plants and pumping plants. ABSTR.]—*Aug. G. Nolte.*

Taking That Bark Out of the Exhaust. H. P. MAXIM. Power, **61:** 10, 375, March 10, 1925. Discusses reason for noisy exhaust from oil engine and gives means of correcting this disturbance.—*Aug. G. Nolte.*

Questions and Answers. FRANKLIN VAN WINKLE. Power. Subjects as follows: **61:** 6, 230, February 10, 1925. Ammonia Charge for New Plant; Pitch of H. R. T. Boiler and Level of Water-Gage Glass; Double-Eccentric Corliss Engine; Terry Filter Cloth; Same Evaporation Capacity with Different Water Levels; An Eight-Pole Rotor in a Six-Pole Stator; Utilization of High Back Pressure; Efficiency of Butt and Double-Strap Joint Quadruple-Riveted; Increasing Temperature of Radiators. **61:** 7, 273, February 17, 1925. Loss in Belt Transmission; Horsepower Constant per Square Inch of Indicator Diagram; Required Point of Cutoff Operating Non-Condensing and Condensing. **61:** 8, 311, February 24, 1925. Effect of Increasing Counter-weight of Flyball Governor; Slip Frequency as Applied to Alternating-Current Motors; Knock with Engine Underloaded; Blowoff Tank for Battery of Boilers; Coal Required to Heat Given Quantity of Water; Point of Cutoff by Slide Valve; Location of Fusible Plugs. **61:** 9, 349, March 3, 1925. Knocking of Pumps and Irregular Pressure in Circulating Lines; Reassembling Crosshead Shoes; Relative Merits of Flush-Front and Overhung Return-Tubular Boilers; Fuel Saving from Returning Condensate of Exhaust Heating-System; Repairing Bag in Boiler Shell; Setting Valves of Two-Cylinder Engine with Reversing Throttle. **61:** 10, 389, March 10, 1925. Wear of Engine Cylinders; Underloading Slide Valve Engine; Relative Holding Power of Flared and Beaded Tube Ends; Lap of Corliss Exhaust Valves; Discharge Check Valve on Ammonia Compressor; Allowance for Expansion of Steam Pipe; Static Electricity from the Blowing of a Safety Valve; Adjusting Crosshead Shoes; Advantage of Butt and Double-Strap Joint; Paradoxical Operation of Check Valve; Delivery of Water by Six-Inch Pipe Line.—*Aug. G. Nolte.*

Cleaner Water for Factory Uses. Factory, 284, February, 1925. Several instances are given where traveling and stationary screens satisfactorily

remove refuse and debris from the water intakes of factories. A beet-sugar factory since installing a screen at the plant end of a sewer reclaims 1500 pounds of beets per day.—*A. W. Blohm.*

Aeration Studies on Creamery Water Purification. MAX LEVINE, LULU SOPPELAND, GEO. W. BURKE. Iowa State College Bulletin, **22**: 10, 1, August 8, 1923. A 2 per cent concentration of skim milk or buttermilk was used as standard "artificial dairy waste." Following conclusions were drawn from experiments: (1) An activated sludge may be developed in about 2 weeks from 2 per cent skim milk; (2) Aeration of 2 per cent skim milk for 16 to 23 hours (with 20 per cent activated sludge and 50 to 60 cubic feet of air per gallon) effected marked reductions in turbidity, acidity, total solids, organic nitrogen and particularly oxygen consumed and oxygen demand; (3) Treatment was more effective with 2 per cent buttermilk than with skim milk; (4) with separately, partially aerated sludge, aeration period of 6 hours and 15.6 cubic feet air per gallon, there was an average reduction of 43.9 per cent solids, 77.7 per cent organic nitrogen and 76 per cent oxygen consumed and oxygen demand; (5) Elimination of about 95 per cent of oxygen requiring constituents from 2 per cent skim milk or buttermilk is not sufficient to yield stable effluents; (6) Employment of activated sludge with view of yielding stable effluents may not be economically practical for a small plant.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Report on Experimental Work Carried out at the Army School of Hygiene to Demonstrate that Chlorine Gas in Association with Ammonia Gas is a more Efficient Sterilizer of Water than Chlorine Gas used alone or Chloros or Bleaching Powder. MAJOR C. H. H. HAROLD and CAPT. A. R. WARD. J. Royal Army Med. Corps, **42**: 6, 414, June 1924 and **43**: 1, 14, July, 1924. Conclusions of the authors are: (1) Anomalous results met with in practice are attributed to inhibition, and that sterilization by chlorine and hypochlorites of waters with high colloid content is unreliable if examination for presence of free chlorine is relied upon; (2) Bleaching powder with ammonia requires 3 p.p.m. in a concentration of 1–10,000 pollution for sterilization, chlorine gas with ammonia 1 p.p.m. for same concentration; (3) Experiments proved chlorine gas superior to either bleach or chloros. Addition of ammonia to the extent of one-third part per million increases the killing power of gas, and to a less extent also that of chloros; but with bleaching powder the additional ammonia actually decreases the lethal action.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Sanitary Engineering in Bengal. Indian Engineering, **76**: 14, 184, October 4, 1924. 1923 Annual Report of Public Health Department of Bengal states that at close of year there were 39 waterworks in operation, serving over 1 million people.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Methods of Water Purification in Providence, R. I. J. W. BUGBEE. Eng. & Contr., **62**: 829–32, 1924. Supply is filtered through slow sand filters at rate of 2.5 million gallons per acre per day, treated with 50 to 100 pounds of

lime and 3 to 8 pounds of chlorine per million gallons. Providence has lead service pipes and lime treatment reduced average amount of lead in tap water from 0.29 to 0.05 p.p.m.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Size and Depth of Sand for Filters. C. M. DAILY. Eng. & Contr., **62**: 827–8, 1924. Daily after extensive tests concludes that 24 inch depth of sand graded from 0.38 mm. to 1 mm. in diameter will give satisfactory results. Sand finer than 0.38 mm. or coarser than 1 mm., is not desirable. Effluent after washing was first clear, then became turbid for about 45 minutes running at ¼ rate; after which it became clear and remained so after raising rate to 3 m.g.d. until tests concluded at 10-foot loss of head. Agar count in effluent roughly follows same changes as turbidity.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Evaporation from Storage Reservoir. ANON. Eng. & Contr., **63**: 128, 1925. Evaporation gage is described. Table giving average evaporation over period of 19 years is included.—*C. C. Ruchhoft.*

Calumet Reservoir and Tunnel. ERNEST A. CLARK. Public Works. **56**: 122–25, 1925. Construction of 2 million gallon reservoir and of seven-foot tunnel carrying 24-inch water main under river is described.—*C. C. Ruchhoft.*

Water Works Statistics for 1924. ANON. Public Works, **56**: 135–50, 1925. Data from 600 municipalities on sizes and lengths of mains laid during 1924. Data on detection of waste and leakage are also given.—*C. C. Ruchhoft.*

Air Lift Pumps. ANON. Public Works, **56**: 22–3, 1925. Conclusions from experiments by University of Wisconsin.—*C. C. Ruchhoft.*

Water Services in Atchison, Kan. ANON. Public Works, **56**: 52–3, 1925. Unusual method of avoiding cutting into pavements for installing water services is described.—*C. C. Ruchhoft.*

Staunton Water Supply Project. WILLARD F. DAY. Public Works, **56**: 88–90, 1925. Construction work on dam for 150 million gallon impounding reservoir and on 14 mile pipe line to convey 2½ m.g.d. to Staunton, Va., is described.—*C. C. Ruchhoft.*

Water Consumption in Cities and Towns. Eng. & Contr., **63**: 531, 1925. Statistics for Massachusetts for 1923 are given.—*C. C. Ruchhoft.*

An English Deep Water Elevator. ANON. Engr. & Contr., **63**: 549–50, 1925. Eight-inch wide belt elevator with steel water carrying elements, delivering 3350 gallons per hour at surface speed of 500 feet per minute from 400 feet well, is described.—*C. C. Ruchhoft.*

The Value of Aëration in Water Purification. MALCOLM PIRNIE. Fire & Water Eng., **75**: 1109, May 21, 1924. At Watertown, N. Y., the Black River

water, dosed with alum at entrance to 5–8 day basin, flows thence to pumping station; is pumped through fountain aërator, falling in spray on bed of broken limestone; then flows through 4 hour coagulation basin to rapid sand filters. Prior to aëration of water it was very active, causing almost universal red water troubles and rapidly destroying service pipes and plumbing. CO_2 content was high and pH, judging from later comparable tests, must have been in neighborhood of 5.4. Effluent colors sometimes exceeded 60 p.p.m.; in 1917 average color was 22 as against average raw water color of 79. In 1922, after addition of aërator, average color of filtered water was 7 with average raw water color of 78; pH is usually one or two-tenths lower than that of raw water; CO_2 is around 2 p.p.m. and complaints of red water have practically ceased. At West Palm Beach, Fla., water is dosed with alum and pumped through nozzles into fine spray which falls into open 8 hour coagulation basin, whence it flows to rapid sand filters. Colors of 200 are reduced below 20 without difficulty. Using dose of 540 pounds of alum per million gallons and with 3 parts of CO_2 in raw water, latter was 30 parts prior to spraying, 16 parts in falling spray, 8 parts on top of filters, and 6 parts in effluent. Further aëration would reduce CO_2 to 2 and increase pH to 6.3 but this would require another pumping; instead, about 35 pounds hydrated lime per million gallons, are added to filtered water entering clear water reservoir. At Danville, Va., it was found that addition of soda ash and alum to raw water, followed by aëration, would cause formation of a perfect floc. Plant is now being rebuilt; soda ash and alum will be added to suction of raw water pump which will force water through a fine spray aërator; from latter water will rise through 10 minute whirling mixer, passing thence through 5 hour basin to filters. In rapid sand filter plant for new water supply for Providence, R. I., all of the variable head remaining between effluent pipes and water level in pure water conduit is to be used in aërating the water. Each filter effluent will be connected with battery of spray nozzles of sufficient area to discharge normal quantity of water under head available when filter is clean. Control is obtained by variable orifice nozzle. Mention is also made of the plant at Long Beach, L. I. Illustrated.—*Geo. C. Bunker.*

Cement-Lined Pipe and Its Advantages. H. Y. Carson. Fire and Water Eng., **75**: 1321, June 18, 1924. Cement lining for cast iron pipe has been developed with following important results: (1) Lining is so dense and intimately attached to cast iron that pipe may be cut with ordinary cleaver or hammer and cold chisel without loosening cement. (2) Lining as originally furnished to Charleston, S. C., was $\frac{1}{16}$ to $\frac{1}{4}$ inch thick, but has now been reduced to $\frac{1}{16}$ inch, or less, so that full nominal diameter of pipe is obtained. (3) Cost of applying lining is at present nominal and in no sense prohibitive. In discussing hydraulics of this pipe statement is made that value of flow coefficient C in Chezy formula is about 25 to 30 per cent above that for new cast iron pipe and does not deteriorate with age.—*Geo. C. Bunker.*

Some Specific Cases of River Pollution. John C. Diggs. Fire & Water Eng., **75**: 1338, June 18, 1924. Wastes from beet sugar plant at Decatur, Indiana, were discharged untreated into St. Mary's River prior to 1922. Ef-

fects of pollution were felt at Fort Wayne, 25 miles below. At instigation of state health department, processes were worked out which resulted in salvaging of much material previously lost with drainage, value of which pays fair return on capital required. Mention is made of case of mine drainage pollution occuring on Patoka River at Princeton as result of unusual circumstances. All fish for distance of several miles were killed and decidedly acid water was supplied to city. Steam plants were put out of service and corrosion of mains, service lines, meters, and consumers' equipment constituted a tremendous loss both to water company and consumers. Correction of stream pollution problem of this character is difficult. Probably practical solution, as far as use of water course is concerned, is, in this case, treatment of water taken from stream. On Sand Creek, near Greensburg, zinc plating factory discharged 5500 gallons of solution containing zinc and sodium cyanide. Waste, passed through city sewers and sewage treatment plant, killed fish for distance of 30 miles below city. Physiological tests showed plating solution to be deadly to fish when diluted with 125,000 volumes of water or in concentrations of 8 p.p.m. Fortunately, so far as reported, only damage done was killing of a few tons of fish; but serious results would have followed if public water supply had been taken from stream. Present in waste was equivalent of minimum lethal dose of cyanide for nearly 12 million persons. Practical treatment process was worked out for removal of all zinc and cyanide from plant drainage. These three cases are typical of many coming before department. Sometimes no solution can be suggested as being practical of operation under existing conditions.—*Geo. C. Bunker.*

The Rational Design of Reinforced Concrete Tanks. ARTHUR S. MILINOWSKI. Mun. and Cnty., Eng., **68**: 6, 288–9, June 1925. *See* this Journal **10**: 4, 571–7, July 1923. It is claimed that with design of Mr. WM. S. HEWETT, A.S.C.E., of Minneapolis, problem of leak-proof concrete tank is at last solved. Paramount consideration is to avoid stressing concrete beyond its elastic limit; cracks thereby developed being difficultly amenable to subsequent waterproofing treatment; whereas leaks due to porosity can be waterproofed without great difficulty. As usually designed, both steel and concrete in tank walls are in tension when tank is full; with low tensile strength of concrete in mind, danger of overstressing is obvious. Not only is this the case, but it has been shown by MATSUMOTO, Bull. **126**, University of Illinois, December 1921, that forces due to tendency of steel to resist shrinkage of concrete during set may become great enough, even where area of steel is only 1½ per cent of that of concrete, to stress concrete beyond its elastic limit. HEWETT escapes these risks by constructing first comparatively thin tank shell of unreinforced, or of very lightly reinforced concrete; this is allowed to set and shrink slowly by keeping it wet. When setting complete, steel reinforcing hoops are shrunk on to outside of shell to considerable degree of tension, thus placing concrete definitely under compression. At this stage, analogy with wooden tank is great. Later, outer coating of concrete or gunite is applied, to protect the steel. Treatment of joint between wall and bottom rests upon same principles. Barnum, Minn., in fall of 1922 erected tank of this design, 20 feet diameter (internal) by 30 feet high; capacity

75,000 gallons. A few leaks developed at first, chiefly due to porosity, and were waterproofed without difficulty. Although tank was subject to exceptionally trying conditions in meantime, careful examination in summer 1924 revealed no trace of dampness anywhere on outside surface. Details of spacing of the 68 reinforcing hoops, upper 24 of which were of $\frac{9}{16}$ inch round steel and rest of $\frac{11}{16}$ inch, are given, and their tensioning to initial stress of around 15,000 pounds by means of turnbuckles described. Cost figures are not included.—*Frank Hannan.*

NEW BOOKS

Erdbaumechanik auf Bodenphysikaelischer Grundlage. KARL TERZAGHI. Leipzig and Wien: Franz Deuticke. Paper; 399 pp.; 7 x 10 inch; 65 line cuts. Reviewed in Eng. News-Rec., **94:** 489, 1925.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Construction of Wells and Boreholes for Water Supply. DUMBLETON, J. E. Crosby Lockwood and Son. 134 pp. 10s. 6d.; by post, 11s. Reviewed in Munic. Eng. **75:** 485, 1925.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Boiler Feed Water (Supply, Softening, and Control in Colliery Practice). N. SIMPKIN. London: H. F. and G. Witherby. Pp. 44. 2s. 6d.; by post, 2s. 8d. Reviewed in Municipal Eng. **75:** 327, March 26, 1925.—*R.E. Thompson.* (*Courtesy Chem. Abst.*)

Kempe's Engineer's Year Book for 1925. Edited by H. R. KEMPE and W. HANNFORD SMITH. Crosby Lockwood and Son. 30s.; by post, 31s. Pp. 2800. Reviewed in Municipal Eng., **75:** 440, April 23, 1925.—*R. E. Thompson.*

Municipal Index, 1925. 2nd Annual Edition. New York: The American City Magazine. Cloth. 521 pp. including advertisements. $4. Reviewed in Eng. News Rec. **94:** 699, April 23, 1925.—*R. E. Thompson.*

SOCIETY AFFAIRS

THE ANNUAL CONVENTION

The forty-fifth annual convention of the American Water Works Association opened at the Brown Hotel in Louisville, Ky., on April 27, 1925.

The morning of the first day was taken up by registration of members and guests.

In the afternoon conferences and committee meetings were held to discuss material for the Manual of Water Works Practice, relating (*a*) to the preparatory treatment of water before filtration and to arrangements and operating efficiencies and economies of rapid sand filters and (*b*) essential statistics for annual reports of water works. The initial meeting of the plant management and operation division was held. This was presided over by W. S. Cramer, chairman of the division.

In opening the meeting Chairman Cramer spoke of the loss sustained by the Association and division in the death of Secretary J. M. Diven, who was also secretary of the division. He called on Dabney H. Maury, who made a short, but eloquent, address appreciative of Mr. Diven, after which those present rose and stood with bowed heads for 15 seconds as a mark of appreciation.

J. E. Gibson read the constitution and by-laws of the division, which were unanimously adopted.

The chairman appointed a nominating committee consisting of W. S. Patton, J. O. Craig, and H. P. Bohmann. The committee was to report at the Tuesday afternoon session with nominations for officers for the division.

Considerable discussion resulted from a member's question as to the size of automatic sprinkler connections for private fire protection. The discussion was participated in by E. F. Dugger, R. F. Wagner, D. R. Gwinn, H. P. Bohmann, J. E. Gibson, D. H. Maury, T. L. Amiss, G. C. Gensheimer, C. H. Bliven, H. M. Ely, P. Carlin, T. Sheahan, W. E. Miller, W. S. Batton, F. M. McElroy, S. H. Taylor, T. H. Allen and J. F. Christy.

The second topic on Cleaning of Well Strainers was discussed by J. F. Christy, H. P. Powell and C. E. Davis.

The Absorption of Surplus by Other Departments was discussed by J. E. Gibson, J. F. Christy, H. P. Powell and Beekman C. Little.

A discussion on Making Extensions Outside City Limits was suggested by J. O. Craig, and was carried forward by J. F. Christy, McDowell, D. R. Gwinn, H. P. Bohmann, B. C. Little and A. T. Luce.

In the evening an informal reception and dance were held in the ball room of the Brown Hotel.

Tuesday, April 28. Morning Session. The opening session of the convention was called to order by President Jordan. The Secretary read the names of those who had passed away during the year, after which a prayer was said by Rev. Harris Mallinkrodt.

President Jordan introduced Mayor Huston Quin, who welcomed the members and guests. The Secretary read the names of officers elected for the ensuing year, as follows:

President, Harry F. Huy; Vice President, George W. Batchelder; Treasurer, William W. Brush; Trustees: District No. 1—R. L. Dobbin; District No. 2—Patrick Gear; District No. 6—Geo. H. Fenkell.

The budget for the year, announced by the Secretary, amounted to a total of $35,000. This was, on motion, carried.

The Committee on the John M. Diven memorial reported. The report was approved by the Convention and is here reproduced.

Your special committee re Diven Memorial, beg leave to report and recommend that the memory of the late J. M. Diven, President of this Association 1891 to 1892 and secretary 1900 to 1924, be commemorated by the giving annually of a bronze medal to be known as the Diven Memorial Medal to the member of this Association who in the opinion of the committee has best served the Association during the year.

Committee on Award—The Executive Committee shall annually appoint three active members of the Association who shall constitute the committee to recommend the award of the J. M. Diven Memorial Medal and this committee shall make its recommendation on the award at the next succeeding meeting of the Executive committee, and may at their option call upon any active member or members of the Association for suggestions or recommendations which may assist them in making an award or consider any recommendations from active members concerning the award.

Rules for Award

1. Competition for the medal shall be restricted to active members of the American Water Works Association—preference being given to those actively connected with the operation or management of public water works.

2. The medal shall be awarded to the active member—not an officer of the

Association—who in the opinion of the Committee during the year has best served the Association.

In making this award, the Committee is to take into consideration the following points:

1. Original papers presented to the Association at the annual or section meetings and appearing in the Journal.

2. Special work done or suggestions made that have furthered the advancement of water works practice.

(Signed) JAMES A. CALDWELL,
JAMES A. CAIRD,
NICHOLAS S. HILL, JR.,
BEEKMAN C. LITTLE,
ALEXANDER MILNE, *Chairman.*

The report of Committee on Water Meters was read by W. W. Brush in the absence of the chairman, Caleb M. Saville. A slight progress was reported in the work of the committee as to the standardization of the dial, both as to question of form of dial and gear train. For the Committee on Brass Fittings, Wm. E. Edwards, chairman, Mr. Brush also reported progress. Reports were adopted.

J. M. Goodell, reporting for J. Waldo Smith on Standard Form of Contract Committee, spoke of the work of the joint committee and told of what had already been accomplished in this work. Two forms of contract had been tentatively prepared—one for building and one for engineering work. These had been approved, but had not yet been printed. The report was adopted.

The report of the Standardization Council was presented by its chairman, George W. Fuller. The report was adopted.

William W. Brush then read article by article the suggested amendments to the constitution. These provided for the affiliation of the Associations in related fields with the A. W. W. A., and allowed members of such Associations to join the organization without the payment of an initiation fee, but the payment of yearly dues. Other amendments provided for eliminating all reference to the Secretary Emeritus and provided that any candidate for office must hereafter have served either on the executive committee or on standing committees of the Association for at least two years. Others regulated the sending out of letter ballot; formed an Administrative Committee; defined personnel and work of Publication Committee; provided that money left over from quota to sections need not be returned to Secretary and provided that two or more sections can hold joint meetings by permission of Executive Committee.

The constitution, as amended, was adopted.

The following honorary members were elected: W. P. Mason, William B. Bull, J. P. Donahue, Dow R. Gwinn and J. Waldo Smith.

The first paper of the session was by Leonard Metcalf, on the "Financial Status of Water Works and Price Trends of Materials and Labor Affecting Them."[1]

The second paper was on "Justification of a Program to Beautify Water Works Properties,"[2] by Charles R. Denman.

The third and last paper of the session was "Description of Reconstruction of Filter Plant at Louisville"[3] by William H. Lovejoy.

April 28. Afternoon Session. The two divisions, Plant Operation and Fire Protection, held separate meetings. At the Fire Protection session these officers were reelected: Nicholas S. Hill, Jr., Chairman; Allan W. Cuddeback, Vice Chairman; and Clarence Goldsmith, Secretary-Treasurer; Executive Committee, George G. Earl, W. E. Miller, F. C. Jordan, H. A. Burnham and V. Bernard Siems. The division was addressed by President Jordan.

N. S. Hill, Jr. spoke of how Mr. Jordan's influence had broadened the viewpoint of the Association and had brought it in close cooperation with two other Associations with the object of reducing the fire losses of the country.

There were many topics discussed at the meeting of the plant operation division, W. S. Cramer, presided. Among other topics, Henry P. Bohmann asked a question as to whether it was better policy to devote space in the water works grounds for school buildings or to devote this space to parking and beautification. Several speakers were in favor of beautification. It was the general opinion that the scholars became a nuisance, destroyed the grounds, and were hard to keep in order, while the beautification of the waterworks was an advantage to all of the people.

George H. Fenkell suggested the special study of the distribution system in order to avoid damage in time of earthquake. This was referred to the Committee on Physical Standards for Distribution Systems.

When the two divisions had completed their executive sessions they joined forces under the chairmanship of Nicholas S. Hill, Jr., chairman of the fire protection division. Mr. Hill spoke at length

[1] JOURNAL, April, 1925, page 375.
[2] JOURNAL, October, 1925, page 289.
[3] JOURNAL, October, 1925, page 352.

on the work of fire protection which the Association had undertaken in coöperation with the two other associations.

The first paper of the session was presented by V. Bernard Siems, on "The Problem of Water Supply for Fire Protection."

This paper was discussed by Chief John J. O'Brien, of the Indianapolis, Ind., fire department, and Clarence Goldsmith.

Dow R. Gwinn presented a paper on the "Business Side of Fire Protection."

A paper was read by L. A. Day, chairman of the Committee on Pumping Station Practice of the Standardization Council on "Recent Pumping Station Practice." The paper was freely discussed by J. N. Chester, F. G. Cunningham, Wm. W. Brush, W. S. Rathbun, M. C. Smith and others. A modification of this material is to be used in the Manual.

At five o'clock the special order for the election of the nominating committee was taken up. Some of the districts not being ready to report candidates, that matter was made a special order for the next morning's session. The final result of the election was as follows, by districts: No. 1, Marcel Pequegnat; No. 2, Geo. H. Finneran; No. 3, W. A. McCaffrey; No. 4, G. C. Gensheimer; No. 5, W. E. Vest; No. 6, W. S. Patton; No. 7, J. F. Christy; No. 8, H. E. Keeler; No. 9, F. M. Randlett.

Three papers, scheduled for the evening session, to be presented by the Water Works Manufacturers' Association, were postponed until late in the sessions. These papers were as follows:

Steel Tanks,[4] by J. E. O'Leary, Pittsburgh-DesMoines Steel Co.; Pipe Coatings, by J. Linden Stewart, Wailes-Dove-Hermiston Co.; Discussion of Water Treatment by Chemicals, by R. J. Quinn, Mathieson Alkali Works.

The entire convention was entertained at a dinner given by the Louisville Water Company in the Brown Hotel on Tuesday evening. Some 850 guests were present.

At 2:00 p.m. the ladies of the convention were taken to the Tudor House to view the Brainard Lennon collections of antique silver and old Sheffield plate. In the evening there was a card party in charge of the ladies committee and under the auspices of the Water Works Manufacturers' Association.

April 29. Morning Session. At. 9:00 a.m. there was a joint

[4] JOURNAL, September, 1925, page 190.

session of the plant operation and fire protection divisions, with Nicholas S. Hill, Jr., in the chair.

A question by a member as to the amount of pressure required at the pumping station aroused much discussion by Nicholas S. Hill, Jr., H. A. Dill, H. P. Bohmann, J. F. Christy, Dow R. Gwinn, F. W. Albert and others.

Another matter provoking much discussion was brought up by H. P. Bohmann. This was the plan of establishing separate valves on each fire hydrant. This question was discussed by D. R. Gwinn, J. F. Christy, E. E. Norman, H. F. Albert, B. C. Little, W. S. Cramer, S. H. Taylor, N. S. Hill, Jr., W. W. Brush and C. N. Avery.

The first paper was by A. C. Hutson on "Modern Views as to Service Reservoirs and Desirable Pressures." Discussed by Nicholas S. Hill, Jr., W. W. Brush, Dow R. Gwinn and C. N. Avery.

A resolution was introduced by C. M. Baker that it was the sense of the American Water Works Association that all cross connections with other systems be discontinued. J. A. Foulks amended this so as to read all polluted systems. It was referred to a committee for revision and later report to this convention.

F. C. Jordan presented to the Association President-elect Harry F. Huy. He announced that, out of 28 cities which had sent formal invitations to the Association to hold its 1926 convention with them, Buffalo, N. Y., had been chosen.

Beekman C. Little, Secretary-Elect of the Association presented a paper on "How Jonesborough Built Its Water Works."[5]

The final paper of the session was by James E. Gibson, chairman of Committee on Standardization of Services of the Council.

April 29. Afternoon Session. The first discussion of the session was on pumping station practice by J. N. Chester, W. S. Cramer, E. M. Nichols, G. H. Fenkell, J. W. Toyne, J. F. Christy, T. Sheahan, W. W. Brush, W. G. Schneider, G. W. Fuller, A. W. Hebbring and F. G. Cunningham.

The Association then took up the discussion of the paper by J. E. Gibson, on "Experiences with Small Service Pipes."[6] Those participating in the discussion were R. B. Morse, W. Luscombe, W. S. Cramer, H. P. Bohmann, W. A. Patton, D. R. Gwinn, W. G. Schneider, H. F. Huy, W. W. Brush, E. F. McEvoy, J. E. Gibson, H. A. Dill, W. E. Taylor, P. Gear and others.

[5] JOURNAL, July, 1925, page 1.

[6] JOURNAL, October, 1925, page 295.

A. L. Fales, Chairman of the Standardization Council Committee on Industrial Wastes in Relation to Water Supply, reported on "Final Status of Suit to Enjoin Melcroft Coal Company, et al., From Polluting Supply of Mountain Water Supply Company." Mr. Fales was unable to be present and the report was read for him. It was discussed by William B. McCaleb, general superintendent of the water companies of the Pennsylvania Railroad and by Leonard Metcalf.

The other paper of this session was "Taxation on Water Plants in Different States on Physical Property, Franchises, Income and Securities." This was by H. Carl Wolf. It was read in his absence by C. A. Emerson, Jr. and was discussed by R. B. Morse, Patrick Gear, S. H. Taylor and C. S. Denman. "Allocation of Sources of Water Supply and Means for Compensation for Diversion in Money and in Kind," was discussed by Wm. Gore, F. W. Randlett, G. W. Fuller, G. W. Pracy and L. Metcalf.

In the evening a smoker was given under the auspices of the Water Works Manufacturers' Association and under the direct charge of Messrs. Warde and James.

At two o'clock the ladies were taken through the park and residential section of Louisville by auto and in the evening there was a theatre party by compliment of the Water Works Manufacturers' Association.

April 30. Morning Session. The "Additional Water Supply Project for East Bay Municipal Utility District in California,"[7] by Arthur P. Davis, was discussed by Chas. B. Burdick and William Gore.

Nicholas S. Hill, Jr., read the joint report of the Committee on Electrolysis. A paper on "Chicago's Experience with Large Land Tunnels,"[8] was read by Arthur E. Gorman. This was discussed by W. W. Brush, Wm. Gore and A. E. Gorman.

The final paper of the session was by W. W. Brush on "Proposed Secondary Chlorination of New York Water Supply After Leaving Open Reservoir at Hill View."

By the time this paper had been concluded it was too late for discussion and this was therefore postponed until later.

April 30. Afternoon Session. Discussion of topics for the Manual consumed this session. Some of the subjects were "Action on Forms to be Embodied in the Manual for Essential Statistics for Annual

[7] JOURNAL, April, 1925, page 424.
[8] JOURNAL, September, 1925, page 175.

Reports of Water Works (including results of Monday conference)" by Leonard Metcalf, and "Coagulation, Sedimentation and Rapid Sand Filters, (including results of Monday meeting of Committee No. 3)," by E. E. Wall.

The resolution on cross-connections, in modified form, was presented and passed by the Fire Protection Division and referred to the Executive Committee. It is reproduced herewith.

WHEREAS cross connections between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever and other water-borne diseases; and

WHEREAS check valves and other similar protective devices can not always be depended upon; Be it

Resolved, That no physical connection should be permitted between a potable public water supply and any other supply except as follows:

1. With another potable public supply.
2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

This prohibition to apply to all piping systems either inside or outside of any building or buildings; and be it further

Resolved, That definite programs should be inaugurated in each municipality to permanently eliminate all other connections.

The remainder of the afternoon was taken up in discussion of the following topics: "Maintaining Crews for Emergency," "Limiting Sizes of Pipes for Fire Service," "Metering Fire Services," "Liability for Fire Losses due to Failures to Raise Distribution System Pressure," "Charges for Fire Protection Services," "Bonds for Fire Protection Service" and "Restrictions for Fire Hydrant Use."

The appointment of a Joint Fire Protection Committee was moved, seconded and approved. This committee was to consist of representatives of the A. W. W. A., the National Association of Fire Engineers and the National Fire Protection Association.

May 1. Morning Session. There were two sessions on Friday. The forenoon meeting was again given to Manual discussion and the first subject was Practice as to Watershed Protection, opened by a report by H. E. Moses. This was discussed by J. A. Foulks, C. A. Holmquist, W. H. Dittoe, W. W. Brush, Wm. Gore, J. E. Gibson and Paul Norcross. The second subject, "Testing Water Works Materials and Supplies."[9] was opened by T. H. Wiggin and discussed by R. S. Weston, Wm. Gore, L. I. Birdsall, M. Pirnie and J. E. Gibson.

[9] JOURNAL, July, 1925, page 38.

J. E. Gibson, newly-elected Chairman of the Plant Management and Operation Division, was presented to the Convention.

"Stimulating Activity in Plumbing"[10] was discussed by August Buschmann. The paper was discussed by F. C. Jordan, D. R. Gwinn, H. F. Blomquist and E. E. Davis.

The final session was devoted to a topical discussion on "The Most Interesting Experience which I have Recently Encountered in Water Works Operation,"[11] and ended by a paper on "Tunnel Experiences,"[12] by Alexander Milne.

The convention then adjourned.

Water Purification Division

Wednesday, April 29, 1925. The morning session was called to order by Vice-chairman James W. Armstrong. The following papers were read and discussed:

Chlorinated Water in the Baking Industry, C. B. Morrison, American Institute of Baking, Chicago, Illinois.

Treated Waters in the Canning Industry, A. W. Stevenson, Research Laboratories, American Canners' Association, Washington, D.C.

Treated Waters in the Beverage Industry, W. H. Lovejoy.

Treated Water in the Swimming Pool,[13] Frederick H. Stover.

Vice-chairman Armstrong appointed a nominating committee to report at the afternoon session: Harry E. Jordan, A. S. Behrman, and J. W. Bugbee.

The attendance at the meeting when counted was 68.

The Division reconvened at 3:00 with Vice-chairman Armstrong presiding. The following papers were read:

Chlorphenol Tastes in Milwaukee,[14] R. W. Cunliffe.

Bacterial Reproduction in Filtered Water, Harry E. Jordan.

Occurrence of Copper in Distribution System Following Copper Sulphate Treatment for Algae, F. E. Hale.

Water Supply for Domestic Animals, Jack J. Hinman, Jr.

The nominating committee appointed at the morning session brought in the following recommendations:

For Chairman, J. W. Armstrong; Vice-chairman, McHarvey

[10] JOURNAL, October, 1925, page 315.
[11] This Journal, page 448.
[12] This Journal, page 450.
[13] This Journal, page 440.
[14] This Journal, page 423.

McCrady; Secretary, Harry E. Jordan; and for members of The Executive Committee, the above officers with A. M. Buswell (retiring chairman), Richard Messer, and W. H. Lovejoy.

The attendance at this meeting was 70.

The dinner of the Water Purification Division was held at the new Elk's Athletic Club at 6:00. There were 98 present. Jack J. Hinman, Jr., presided. Short talks were made by M. N. Baker, Lewis I. Birdsall, John M. Goodell, Robert Spurr Weston, and J. W. Armstrong. Harry E. Jordan presented the proposed constitution and by-laws as prepared by a committee consisting of himself, Lewis I. Birdsall, A. M. Buswell, and Almon L. Fales. The proposed constitution and by-laws which changed the name from Chemical and Bacteriological Section to Water Purification Division were unanimously accepted. The meeting of the Division was then adjourned.

WISCONSIN SECTION

The Wisconsin Section met jointly at 2:00 p.m. on May 27, 1925, with the Wisconsin League of Municipalities in accordance with the program below.

On May 28 the meeting was called to order in the hearing room, State Capitol, by Chairman W. D. Leonard, subsequent to which the program was taken up in regular order. At the conclusion of the regular program the nominating committee previously appointed reported as follows:

For Chairman, C. P. Gross; for Vice Chairman, Wm. Koehn; for Director, B. B. Hayford.

(Signed) L. A. Smith,
H. P. Bohmann,
H. W. Jackson.

A motion was made and carried that the Secretary cast a unanimous ballot for the above named officers.

Motion was made and carried that, as a routine procedure, the Vice President regularly act as Chairman of the membership committee. It was the consensus of opinion that more active efforts be made to build up the membership of the organization. There were 21 members and 28 guests in attendance at the meeting.

The program was as follows:

May 27

10:00 a.m. Registration.
2:00 p.m. Joint meeting with Wisconsin League of Municipalities. Addresses.
3:00 p.m. "Increasing the Water Supply," W. G. Kirchoffer.
3:40 p.m. Discussion, C. M. Baker.
3:50 p.m. General Discussion.

May 28

9:00 a.m. Address by Chairman and appointment of committees.
9:20 a.m. Secretary-Treasury Report.
9:30 a.m. Membership Committee Report.
9:40 a.m. Report of National Convention, H. P. Bohmann.
10:00 a.m. "Isolated Deep Well Pumping," B. B. Hayford.
10:20 a.m. Discussion, L. A. Smith.
10:30 a.m. "Softening Artesian Well Water," John C. White.
11:00 a.m. Discussion, Prof. O. A. Haugen.
11:10 a.m. General Discussion.
11:20 a.m. "Iron Removal from City Water," C. P. Gross.
11:40 a.m. Discussion, C. M. Baker and L. A. Smith.
11:50 a.m. General Discussion.
12:15 p.m. Luncheon (Waterworks Men).
2:00 p.m. Report of Nominating Committee and Election of Officers.
2:10 p.m. Topic Discussion.
Reading of Meters and Methods of Billing, O. J. Ronge.
Cross Connections, C. M. Baker.
Pumping Station Records, L. A. Smith.
Uniform System of Accounting, P. A. Reynolds.
3:45 p.m. Round Table Discussion.
Adequate Distribution System Enforcement.
Reservoir Construction.
Freezing of Hydrants with Surface Water.
Question Box.